Factors Associated with Use of Safety-Engineered Needles and Hands-Free Techniques: Current Practices among Operating Room Nurses

by

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A dissertation submitted to the Johns Hopkins University in conformity with the requirements for the degree of Doctor of Public Health

Baltimore, Maryland
March 2016

ABSTRACT

Background – Injuries from contaminated needles and other sharp medical devices continue to present serious occupational health concerns for healthcare workers. This poses significant risk of infection from potentially life-altering bloodborne pathogens (BBPs) such as Hepatitis B (Hep B), Hepatitis C (Hep C) and the Human Immunodeficiency Virus (HIV). Previous research has shown that while percutaneous injuries (PIs) in nonsurgical hospital settings have decreased by approximately 31.6% over the period from 1993 through 2006, there was an opposing trend in surgical settings. (Jagger et al., 2010) According to researchers, PIs in the operating room (OR) increased by 6.5% during the same time period. (Jagger et al., 2010) Hypodermic needles are among the devices most commonly associated with PIs and safety-engineered needles are commercially available and effective at reducing needle sticks. In fact, the researchers attributed much of the successful sharps-injury reduction in non-surgical settings to an increased use of sharps with engineered sharp-injury protections (SESIPs) such as safety-engineered hollow-bore, hypodermic needles. (Jagger et al., 2010)

The US Department of Labor, Occupational Safety and Health Administration (OSHA) requires use of engineering and work practice controls to eliminate or minimize exposure to bloodborne pathogens. There is evidence that use of a hands-free passing technique (HFT), a work practice that eliminates the hand-to-hand passing of contaminated instruments during surgical procedures, has had success in reducing sharps injuries when used regularly. [Folin, 2000; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b)] Yet, among surgical staff, compliance with use of such safer work practices with demonstrated success appears to be lower than expected.

Objectives – The purposes of this study were to: 1) characterize safety behaviors among OR nurses practicing in the United States through evaluation of their work environment and their level of compliance with the use of safety-engineered hollow-bore needles and their practice of hands-free technique while passing contaminated sharps in the OR; 2) assess the influence of various individual-level and organizational factors associated with the two safety practices; and 3) discuss possible intervention methods to increase compliance of the two safety measures of interest among surgical nursing staff.

Methods – We conducted a descriptive correlational study using a cross-sectional survey that was administered to currently practicing operating room nurses who were members of the Association of peri-Operative Registered Nurses (AORN). We gathered demographic information as well as information regarding the work environment and safety practices related to sharps used in ORs. A modified PRECEDE behavioral model was used to demonstrate how predisposing, enabling and environmental (i.e., organizational) factors affect behavior among OR nurses. In this study, the Health Belief Model (HBM) was used in the assessment of associations between individual-level perceptions (i.e., perceptions of susceptibility, severity, barriers to use, and perceptions of benefits) and the nurses' intention to use of safety-engineered needles and HFT. Chi square and logistic regression analyses were used to evaluate the associations between the independent variables (e.g., demographic characteristics of respondents, work practices, facility policies, training experiences, etc.) and the nurses' use of safety engineered hypodermic needles and hands-free passing techniques in the OR.

Results - The reported rates of use of SESIP needles and of HFT were largely infrequent—rates of regular use were reported to be 46% and 42%, respectively. The PRECEDE factors identified as the strongest independent predictors of SESIP needle use were: low perceived barriers (e.g., not interfering with procedures), high views related to enabling factors (e.g., high perception of one's skills in using SESIP needles) and environmental factors (e.g., mandatory policy to use), and training. Similar findings were identified with HFT use; however, an additional construct, high perceptions of benefits to the use of HFT also emerged as a significant independent predictor of HFT use. Training on how to use SESIP needles was found to have a significant direct effect on SESIP needle use—those who reported receiving training were three times more likely to use SESIP needles compared with those who were untrained. Other work practices/policies found to be strongly associated with increased use of SESIP needles and HFT include: the practice of announcing sharps transfers and avoiding recapping used needles; and inclusion in the decision of SESIP selection.

Conclusions – This study supports findings of other studies that show the influence of perceived barriers, enabling factors, existing institutional policies and training on compliance with safety practices. (Stringer et al., 2009(b), Stringer et al., 2011; Osborne, 2003(a); Gershon, 1995) Among the important findings in this study was that the awareness of existing institutional policies was associated with a five-fold increase in the nurses' compliance with each of the two safety behaviors. The next step should be to identify interventions that are aimed at designing methods of worker education that take into account individual level perceptions and behaviors, such as barriers and enabling factors, and at increasing the existence and awareness of effective mandatory use policies at the institutional level.

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ACKNOWLEDGEMENTS

First and foremost, I thank God for giving me strength and determination along this journey and for providing wonderful helpers to assist and encourage me at the difficult points when my own strength was not enough.

I am forever indebted to Jackie Agnew, PhD for being the most amazing advisor, mentor, teacher, and friend—without your guidance and encouragement it would not have been possible to balance the demands of working full time while writing my dissertation. I would also like to thank Andrea Gielen, PhD, Keshia Pollock, PhD, Peter Lees, PhD, and Elayne Kornblatt-Phillips, PhD for all of their help. Thanks to each of you for believing in my project and supporting me through the process.

Along the way, several other faculty and fellow Hopkins students were helpful and supported my work, including: former faculty member, Lynn Goldman, MD, MS, MPH; Paul Locke, JD, DrPH, Maureen Cadorette, PhD, RN, and Jennifer Hartle, DrPH, MHS. This process was made much easier with the help of Nina Kulacki, Jane Taylor, Courtney Mish and Keith Choi —I am grateful to each of them for playing instrumental roles in helping me to navigate the various forms and to meet all the major milestones along the way.

I am grateful to the nurses who gave their time to help shape my questionnaire and to those who participated in my survey. A special thanks to Germaine Williams, RN, a nurse at Johns Hopkins University Hospital who welcomed me into her surgical department, introduced me to her coworkers and recruited their help in my pilot study. She answered countless questions about the day-to-day operations of her surgical specialty area, and the data for my pilot study were collected because of Germaine's willingness to help. I also extend enormous gratitude to the Association of peri-Operative Registered Nurses (AORN) for their collaboration and support. Special thanks to Mary Ogg, RN, a peri-operative nurse specialist who graciously assisted me in making contacts within AORN and to Brian Tepp, Director of Membership, who ultimately managed the dissemination of my survey to AORN members nationwide.

Of course, none of this would have been possible without support from family and friends. My friends Tanya Geiger and Yessika Mashinski were huge supporters. I extend a huge thanks to my family for their love, support and understanding throughout the many years it took to complete this process—my sister, Jennifer Williams Clarke was my sounding-board when the journey got tough (and it did, many, many times); my father, Bert Williams was incredibly understanding at times when my project distracted me from fully participating in family functions. I dedicate my dissertation to my mother, Doris Williams, whose unwavering confidence in my ability to accomplish this goal was often times much stronger than my own—she was my biggest supporter, encourager and cheerleader. I could not have done this without my mother's gentle words "*I know you can do it; you'll get it done".* She repeated those words in almost every conversation with such certainty that it encouraged, motivated and bolstered my own self-confidence—my mother has helped me through more rough spots in my doctoral journey (and in life) than she will ever know!

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ABBREVIATIONS

ACS	American College of Surgeons
ANA	American Nurses Association
AORN	Association of peri-Operative Registered Nurses
BBP	Bloodborne Pathogens
CMS	Centers for Medicare and Medicaid Services
HBM	Health Belief Model
HFT	Hands-Free Technique
NIOSH	National Institutes for Occupational Safety and Health
NSPA	Needlestick Safety and Prevention Act
OR	Operating Room
OSHA	Occupational Safety and Health Administration
PI	Percutaneous Injury
SESIP	Sharps with Engineered Sharps-Injury Protections
TJC	The Joint Commission

CHAPTER 1. INTRODUCTION

1.1 BLOODBORNE PATHOGENS RISK IN HEALTHCARE

Injuries from needles and other sharp medical devices that are contaminated with blood present serious occupational health concerns for workers in the healthcare industry. Contaminated sharps are potential sources of exposure to numerous life-altering infectious diseases, including human immunodeficiency virus (HIV), Hepatitis B virus (HBV), and Hepatitis C virus (HCV). The Centers for Disease Control and Prevention (CDC) has estimated that hospital workers are exposed to more than 384,000 percutaneous injuries (PIs) each year. (Panlilio, 2004) Among all United States healthcare workers, it has been estimated that approximately 600,000 to 800,000 needlestick/sharps injuries occur annually. (Cooley, 2004; Gabriel, 2004) But these estimates may underrepresent the burden of PIs to healthcare workers, since it is believed that as much as 56.6% of all needlestick injuries go unreported. (Panlilio et al., 1998; Doebbeling et al., 2003; Vose, 2009)

The following approximations have been made regarding risk of seroconversion from PIs for all healthcare workers: 0.3% risk for HIV, up to 31% for HBV and 1.8% to 10% for HCV. (CDC, 2001; Taylor, 2006) Surveillance data through December 2010 documented 57 reported occupationally acquired cases of HIV infection in the United States (CDC, 2011; Do et al., 2003; Health Protection Agency, 2005), and an additional 143 cases are linked as being possibly associated with work exposure. (CDC, 2011) The most recent possible new case of occupationally acquired HIV reported to CDC occurred in 2009. (CDC, 2011) Of the 57 documented seroconversion cases, 45 resulted from injuries sustained from hollow-bore needles and two resulted from scalpel-induced injuries. (Do et al., 2003) The CDC reported the following routes of exposure for the 57 cases that resulted in infection: 48 percutaneous (puncture/cut injury); five mucocutaneous (mucous membrane and/or skin); two both percutaneous and mucocutaneous; and two of unknown route. (CDC, 2011)

Most sharps injuries are preventable. The Occupational Safety and Health Administration (OSHA) regulates worker-protection with requirements detailed in 29 CFR 1910.1030, the Bloodborne Pathogens (BBP) Standard of 1991. In 2000, Congress passed the Needlestick Safety and Prevention Act (NSPA) that mandated further updates to the BBP Standard, and OSHA responded by updating the standard in 2001. The regulation requires employers to use a combination of methods, including engineering controls, work practice controls, personal protective equipment (PPE), and employee education and training, to prevent sharps injuries and other incidents that could lead to occupational transmission of bloodborne pathogens. Engineering controls are considered the primary means of protection, followed by safer work practices and, as a tertiary means of control, personal protective equipment (PPE).

Research has shown that the three instruments reported to be most commonly associated with PIs in the operating room (OR) are suture needles (43.4%), scalpels (17%), and syringes (12%). (Jagger et al., 2010; MDPH, 2008) Engineered devices have been shown to be effective at reducing PIs in healthcare, and safer engineered options are available for all three devices that are most commonly associated with PIs in the OR. Nevertheless, in a study published in April 2010, researchers evaluated the trend in PIs from 1993 through 2006 and estimated that the majority of the decline in needlestick injuries over that time period had occurred in specific practice areas in healthcare, namely in non-surgical settings. (Jagger et al., 2010) Researchers estimated that approximately 138,357 needlestick injuries were prevented in each year of the post-NSPA period. (Phillips et al., 2013) There remains a concern that, while rates are decreasing in non-surgical healthcare settings, the rate of injuries in the OR is increasing. (Jagger et al., 2010) This highlights the specific problem in the OR, where injury rates are trending in an inverse direction as compared to other parts of the hospital.

Anecdotal evidence suggests that for a significant proportion of surgical procedures, surgeons opt against using safety-engineered scalpels due to the difference in the “feel” and manipulation of the protective sliding sheaths that are designed to cover the blade after use. Suture needles are responsible for the largest proportion of PIs in the OR, and blunted (safety-engineered) sutures have been determined to be effective at closures of soft internal tissues and fascia. (OSHA/NIOSH Bulletin, 2007) Yet, widespread acceptance and use of blunted sutures has been slow. Again, anecdotal evidence suggests a preference by surgeons for sharper sutures, even when suturing soft tissue that can be effectively closed with blunted ones. Many external closures can also be made safer through the use of surgical bonds/glues and tapes, thereby avoiding sharp sutures altogether. Nevertheless, advocates for safer surgical practices have difficulty convincing practitioners in surgical settings to adopt and use these alternatives that could greatly reduce the incidence of potentially life-altering PIs.

The performance of surgical procedures exposes practitioners to a higher degree of blood than nonsurgical procedures. The presence of blood in large quantities increases the potential risk of exposure to bloodborne pathogens. Also, as previously mentioned, of the 57 seroconversion cases documented by the CDC, 45 (approximately 80%) resulted from injuries sustained from hollow-bore needles. (Do et al., 2003) Though hollow-bore needles account for a lower proportion (approximately 12%) of PIs in the OR than solid devices like suture needles (approximately 43%) or scalpels (approximately17%), the risk of a seroconversion from injuries resulting from a hollow-bore needle is considered greater than with solid instruments. This is due to a combination of assumptions, including: 1) a higher likelihood that the hollow-bore needle will contain the patient's blood; 2) an increase in potential severity of the injury; and 3) a high likelihood of the injury resulting in blood loss for the injured employee when a hollow-bore needle causes the injury. (Do et al., 2003) However, we are aware of successful implementation of sharps with engineered sharps-injury protection (SESIP) needles in nonsurgical environments. (Orenstein, 1995; Clarke, 2002; Slater and Whitby, 2007; Whitby, 2008; Jagger et al., 2010; Valls, 2007)

In addition to the availability of several engineering options, OR practitioners also have available safer work practices that, if used, can minimize or reduce the risk of PIs. The use of hands-free passing techniques (HFT) is strongly recommended by OSHA, the National Institutes for Occupational Safety and Health (NIOSH), the Association of peri-Operative Registered Nurses (AORN), practicing surgeons, and the American College of Surgeons (ACS) as a method of minimizing sharps injuries to OR staff. (OSHA CPL, 2001(b); Berguer, 2004; Berguer, 2005; ACS, 2007) HFT allows practitioners to create a safe or neutral zone within or around the surgical field where sharps can be placed and retrieved rather than having surgeons and assistants pass sharps from hand-to-hand.

(Stringer et al., 2002) The hand-to-hand transfer is a dangerous practice that often leads to PIs. A number of researchers have examined the use of HFT. [Eggleston, 1997; Folin, 2000; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b); Osborne, 2003(a); Jeong, 2009] The Canadian researchers Stringer et al. have conducted several of the studies that have examined use of HFT. In the majority of studies that have looked at effectiveness of HFT use, findings showed that use of HFT was associated with decrease in sharps injuries. [Folin, 2000; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009(b)] There is evidence from Stringer's studies showing that the use of HFT in surgical settings is likely to reduce PIs in the OR by as much as 35% for all surgeries in settings where the practice was used more than 75% of the time. [Stringer et al., 2009(b)]

1.2 RATIONALE FOR STUDY

Given that the preponderance of previous studies exploring the use of HFT in the OR have largely been conducted outside of the United States, this study provides valuable insight to address an important research gap: i.e., assessing use of these work-practice controls among OR nurses in the United States. Furthermore, there has been substantial work done using behavioral and social sciences theories with a focus on perceptions of safety related to patient safety as opposed to worker safety. In the studies that have used these methods to assess worker safety, the focus has, in large part, been on the use of personal protective equipment (PPE). [Osborne, 2003(a); Osborne, 2003(a)] It is unknown whether the drivers for PPE use are the same as those for use of safety-engineered sharps devices. Therefore, this research addressed the drivers for use of safety-engineered hypodermic needles in the OR. This information could be valuable in setting priorities for interventions specific to the use of syringes and the practice of HFT in the OR setting.

1.3 SPECIFIC AIMS AND HYPOTHESES

1.3.1 Specific Aim 1

In a sample of members of the Association of peri-Operative Registered Nurses (AORN), evaluate the demographics and characteristics of the work environment, as well as the level of compliance with the use of safety-engineered hollow-bore needles and the practice of hands-free technique while passing contaminated sharps in the OR.

Hypotheses

1a. Individual characteristics such as age, years of practice, and specialty are positively associated with nurses' level of compliance with the two specific sharps safety-related behaviors of interest in the OR.

1b. Characteristics of nurses' place of employment such as size of facility, existence of policies, type of setting (e.g., public versus private settings) are positively associated with nurses' level of compliance with the two specific sharps safety-related behaviors of interest.

1.3.2 Specific Aim 2

Using a modified PRECEDE behavioral model, characterize the influence of individual characteristics of nurses and their perceptions of sharps safety, as well as environmental (organizational) factors on the OR nurses' compliance, and compare predictive models for compliance with an engineering control (SESIP needle) versus a work practice control (HFT).

Hypotheses

2a. Individual-level perceptions (e.g., perceptions of greater levels of susceptibility/risk to Hepatitis B, C/HIV, perceptions of greater seriousness of Hep B, C/HIV infection, perceptions of significant barriers to use and of positive benefits to self and patients from practicing two specific sharps safety-related behaviors) are positively associated with nurses' compliance with these behaviors during surgery.

2b. Environmental factors (e.g., mandatory policies) are more strongly associated with OR nurses' compliance with the use of safety-engineered needles than with HFT.

1.3.3 Specific Aim 3

Explore possible intervention methods to increase sharps-injury prevention practices in surgical settings.

1.4 DISSERTATION ORGANIZATION

The remainder of the dissertation is organized as follows.

In Chapter 2, a summary of background information is presented, beginning with relevant paragraphs and subparagraphs of the governing law and regulation that set policy for workplace safety related to the handling of sharp medical devices. Needlestick injury surveillance systems are described, along with a summary of what is known about sharps injuries in operating rooms. Additionally, Chapter 2 provides a description of options for safer hypodermic needles and theories on potential barriers to full compliance with sharps safety law(s) in ORs.

Chapter 3 is the first of two manuscripts that present the study results. Manuscript 1: "Characterizing safety behaviors among operating room nurses in the United States," is a cross-sectional study describing characteristics of safety behaviors among OR nurses. The study, which addresses Specific Aim 1, examined the association between demographic characteristics and nurses' use of hands-free passing techniques (n=427) and safer needle devices (n=306).

Manuscript 2: "Influence of perceptions of safety on use of two safety techniques in the operating room," is Chapter 4. This descriptive correlational study, which addresses Specific Aim 2, evaluated the association between individual-level beliefs and organizational factors on OR nurses' use of hands-free passing techniques (n=427) and safer needle devices (n=306).

Chapter 5 is a policy discussion that, in accordance with Specific Aim 3, reviews the interrelated benefits of research, public and organizational policy, and advocacy in addressing sharps injuries. This chapter discusses notable findings of the two studies, as well as policy and research recommendations.

Appendices include: the theoretical framework for the study; the survey instrument; components of the PRECEDE model; and additional supporting tables.

CHAPTER 2. BACKGROUND

2.1 CURRENT U.S. REGULATIONS AND POLICIES

In recognition of the seriousness of this occupational health risk, in 1991, the Occupational Safety and Health Administration (OSHA) promulgated the Bloodborne Pathogens Standard (29 CFR 1910.1030), which mandated worker protection through the use of a combination of methods, including engineering controls, work practice controls, personal protective equipment (PPE), and employee education and training. The requirements of the OSHA standard align with the conventional hierarchy of controls. Section 1910.1030(d)(2)i) states:

> Engineering and work practice controls shall be used to eliminate or minimize employee exposure. Where occupational exposure remains after institution of these controls, personal protective equipment shall also be used. [OSHA standard,1991; 2001(a)]

The standard gave the following definition for work practice controls [29 CFR 1910.1030(b)]:

> *Work Practice Controls* means controls that reduce the likelihood of exposure by altering the manner in which a task is performed (e.g., prohibiting recapping of needles by a two-handed technique). [OSHA standard, 1991; 2001(a)]

OSHA laid out its mandates to promote use of engineering controls and good work practice(s), and it explicitly prohibited certain procedures/activities considered to be poor work practices, as evidenced by the following sections:

> Section 1910.1030(d)(2)(vii) states, [c]ontaminated needles and other contaminated sharps shall not be bent, recapped, or removed except as noted in paragraphs (d)(2)(vii)(A) and (d)(2)(vii)(B) below. Shearing or breaking of contaminated needles is prohibited. [OSHA standard, 1991; 2001(a)]

> Section 1910.1030(d)(2)(vii)(A) states, [c]ontaminated needles and other contaminated sharps shall not be bent, recapped or removed unless the employer can demonstrate that no alternative is feasible or that such action is required by a specific medical or dental procedure. [OSHA standard 1991; 2001(a)]
>
> Section 1910.1030(d)(2)(vii)(B) states, [s]uch bending, recapping or needle removal must be accomplished through the use of a mechanical device or a one-handed technique. [OSHA standard 1991; 2001(a)]
>
> Section 1910.1030(d)(2)(viii) states, [i]mmediately or as soon as possible after use, contaminated reusable sharps shall be placed in appropriate containers until properly reprocessed. [OSHA standard 1991; 2001(a)]

Initial development of effective engineering controls and their adoption and use in healthcare settings were limited. In 2000, Congress passed the Needlestick Safety and Prevention Act (NSPA), which directed OSHA to update the Bloodborne Pathogens Standard by clarifying the need for healthcare workers to be protected through the utilization of "safety-engineered sharps injury protections (SESIPs)," work-practice controls, and annual evaluation of available SESIPs to ensure use of the most feasible safety devices for worker protection. [OSHA standard, 2001(a)] A few important new mandates that were included in the updated OSHA regulations were the requirements for healthcare settings to: a) evaluate newer SESIP devices on an annual basis; b) include non-managerial employees in the selection of safer devices; c) select SESIP devices that are more effective and document reasons for not doing so in the facility's written exposure control plan; and d) maintain a sharps injury log to record percutaneous injuries from contaminated sharps. The updated OSHA standard, at 29 CFR 1910.1030(b), gave the following specific definition for SESIPs:

> *Sharps with engineered sharps injury protections* means a non-needle sharp or a needle device used for withdrawing body fluids, accessing a vein or artery, or administering medications or other fluids, with a built-in safety feature or mechanism that effectively reduces the risk of an exposure incident. [OSHA standard, 2001(a)]

Following the update of the OSHA standard, manufacturers of SESIP devices significantly improved the designs and options of available SESIP technology, and the use of safer devices by healthcare settings increased.

Also in 2000, the Department of Health and Human Services (DHHS) included the reduction of occupational sharps injuries among healthcare workers as one of the occupational health objectives in the Healthy People 2010 (HP2010) initiative. (DHHS, 2000) A goal was set to reduce overall needlestick injuries among healthcare workers by 30% by the year 2010. (DHHS, 2000) The CDC's final report from the HP2010 initiative reported that we achieved approximately 60% of this goal. By this estimation, needlestick injuries among healthcare workers have been reduced by roughly 18% between 2000 and 2010. Despite the fact the goal was not fully achieved, this goal was not included in the Healthy People 2020 objectives. (HP2020 website)

Several studies have reported some decline in percutaneous injuries (PI) rates from hollow-bore needles and intravenous (I.V.) line connectors, which has been largely attributed to the development and use of improved SESIPs and needleless I.V. systems. (Jagger et al., 2008; Jagger et al., 2010) These developments are believed to be due, in large part, to legislation in support of sharps safety.

2.2 NEEDLESTICK INJURY SURVEILLANCE

There have been two national surveillance mechanisms developed for the collection of needlestick injury data in the United States. The first was the Exposure Prevention Information Network (EPINet). EPINet, a data collection system developed in

1992 at the University of Virginia's International Healthcare Worker Safety Center, which gathered voluntarily submitted data from hospitals across the country. The EPINet surveillance system has collected data from a cumulative total of 87 different facilities nationwide since its inception. Information from the EPINet database proved very useful over the years, despite the small sample of facilities, which represents a small proportion of the total number of facilities that exist nationwide. The second nationwide surveillance mechanism was the National Surveillance System for Health Care Workers (NaSH), which also collected hospital-based needlestick injuries submitted voluntarily by facilities nationwide. The NaSH database, collected by the CDC, operated from 1995 until 2007. Through NaSH, the CDC collected sharps injury data from a total of approximately 60 facilities during the years the database was operational. A mandatory database was established in the state of Massachusetts in 2001. The Massachusetts Sharps Injury Surveillance System (MSISS) is a statewide surveillance system that requires annual submission of needlestick injury data from all hospitals licensed by the Massachusetts Department of Health (MDPH). This state-run database continues to collect information from approximately 100 hospitals that are required to report sharps injury information in order to maintain funding from the state.

Through a collaboration initiated by the CDC and NIOSH, there is currently work underway to develop a more robust surveillance system that would capture needlestick injuries across the country. The current project expands on the National Healthcare Safety Network (NHSN) with a module dedicated to collecting sharps injury information. The NHSN is a part of the CDC's Occupational Health Safety Network (OHSN), which already collects other valuable information from healthcare settings enrolled in the network. There were approximately 116 facilities enrolled and submitting other occupational health information to the OSHN as of January 2014. (Gomaa et al., 2014)

Despite OSHA's strict prohibition of contaminated needle recapping, the MSISS data for 2010 showed that 61 injuries occurred while recapping a needle across hospitals in Massachusetts. This represented approximately 7.2% of all sharps injuries involving hypodermic needles/syringes. (MDPH, 2011) A study by Jagger et al. reported that approximately 10% of needlsticks involving hypodermic needles between 1993 and 2006 occurred while recapping a used/contaminated needle. (Jagger et al., 2010) (See Figure 2.3)

In 2010, a study using EPINet data reported that, while PIs in nonsurgical hospital settings have decreased by approximately 31.6% over the period from 1993 through 2006, an opposing trend exists regarding PIs among workers in surgical settings, which had a reported increase of 6.5% over the same time period. (Jagger et al., 2010) These data are illustrated by Figure 2.1. Research has shown that the three instruments that are reported to be most commonly associated with PIs in the operating room are suture needles (43.4%), scalpels (17%), and syringes (12%). (Jagger et al., 2010; MDPH, 2008) Disposable syringes with varying gauges (diameter sizes) of hollow-bore, hypodermic needles are used in the ORs by anesthesiologists and by the surgical staff. Discussions with a practicing surgeon and with several operating room nurses reveal that, anecdotally, there seems to be an increasing frequency of disposable syringe use by surgeons to administer local anesthetics (personal communications, June 2010 and April 2011). This is perhaps in an attempt to minimize patients' exposure to high concentrations of general anesthetics.

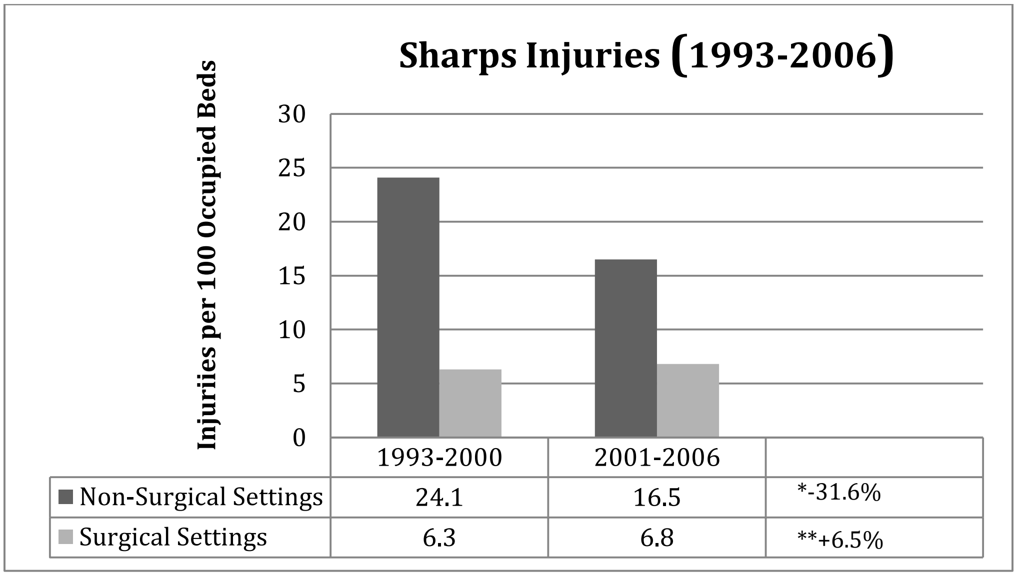

Figure 2.1. Injury rates in surgical versus nonsurgical hospital settings in the United States before and after the Needlestick Safety and Prevention Act of 2000. Data are from the Exposure Prevention Information Network (EPINet), International Healthcare Worker Safety Center, University of Virginia Health System. (Jagger et al., 2010)
*Ratio of injury rates: 0.68 (95% CI 0.66 to 0.71); $p<0.0001$ (Change = -31.6%).
**Ratio of injury rates: 1.065 (95% CI 1.013 to 1.119); $p<0.05$ (Change = +6.5%).

According to operating room surveillance data published by the MDPH in 2008, conventional devices (i.e., devices without safety engineered features) were involved in approximately 78% of reported injuries in surgical settings. (MDPH, 2008) Hypodermic or other hollow-bore needles accounted for approximately 20% of the conventional devices involved in these reported injuries. (MDPH, 2008) It is widely accepted that the risk of transmission of disease is increased for needlesticks resulting from a hollow-bore needle, such as those used in administering anesthetic injections, as compared to injuries from solid sharps, such as suture needles. This is due to a combination of assumptions, including: 1) a higher likelihood that the hollow-bore needle will contain the patient's blood; 2) an increase in potential severity of the injury; and 3) a higher likelihood of the injury resulting in blood loss for the injured employee when a hollow-bore needle causes the injury. (Do et al., 2003)

Jagger et al. reported that 30.3% of OR injuries from 1993 through 2006 were sustained by OR nursing staff. Surveillance further shows that 51.9% of disposable syringe-related injuries occurred during use or while passing instruments. (Jagger et al., 2010) Considering that nurses are not likely to be the primary users of needles and other sharp devices in the OR, it is reasonable to assume that nurses sustain most of their injuries during the passing of instruments, at some point during a multi-step procedure, or at the point of disposal. Jagger et al. illustrated (from data spanning 1993 to 2010) that the largest proportion of sharps injuries reported by surgical nurses indeed occurred during passing and between steps. (Figure 2.2) (Jagger et al., 2010) This presents an opportunity to assess ways to intervene in these pathways where most injuries to nurses are likely to occur.

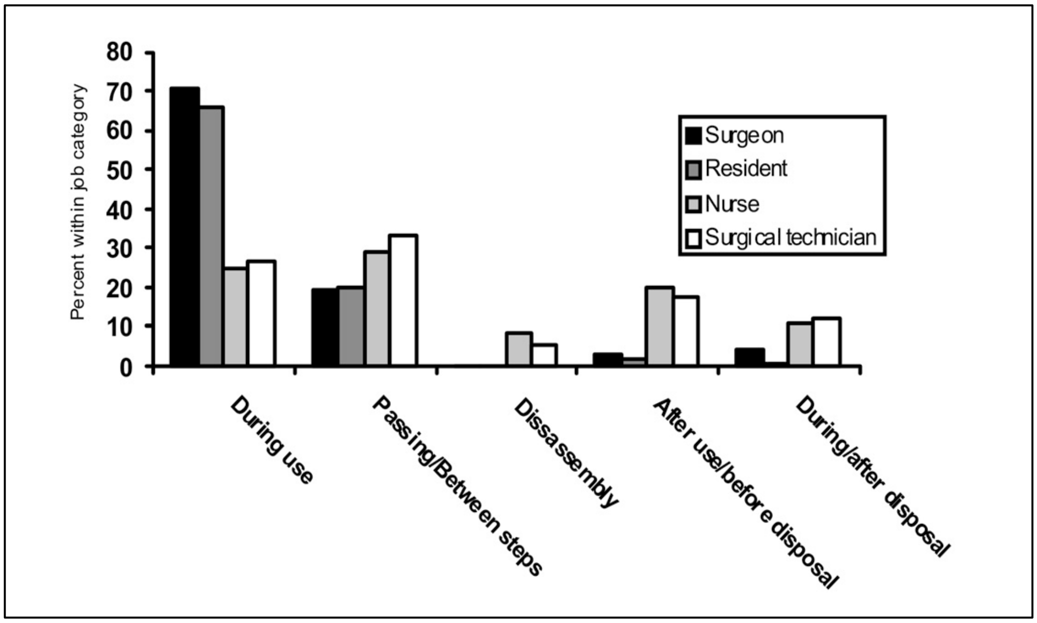

Figure 2.2 Mechanism of injury by job category of surgical personnel. Data are from the Exposure Prevention Information Network (EPINet), International Worker Safety Center, University of Virginia Health System. (Jagger 2010)

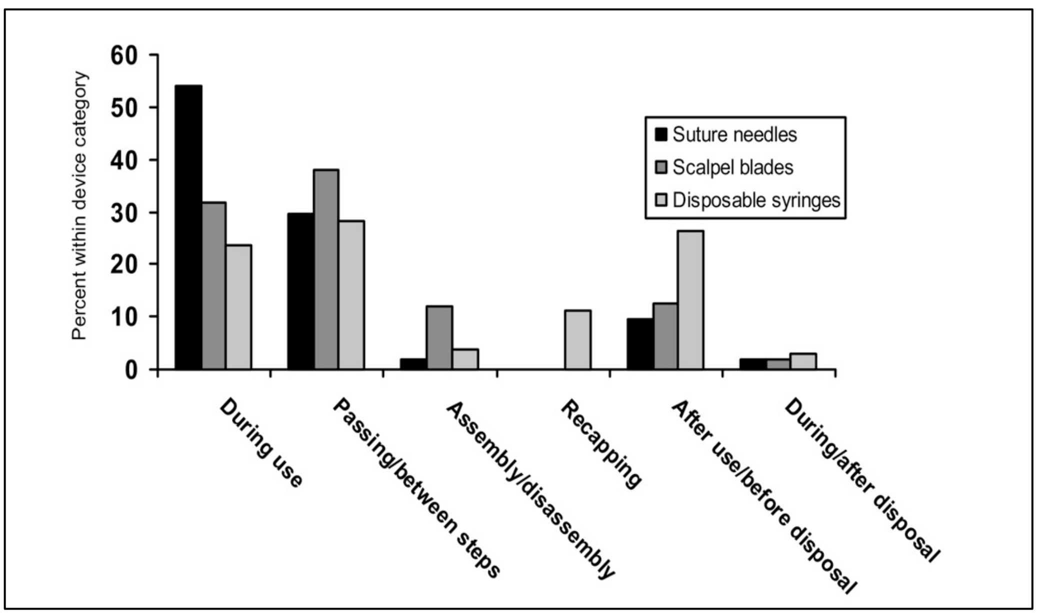

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Figure 2.3 Mechanism of injuries caused by suture needles, scalpel blades, and disposable syringes. Data are from EPINet, International Worker Safety Center, University of Virginia Health System. (Jagger 2010)

Researchers have documented the effectiveness of safety-engineered sharps in reducing injuries from contaminated sharps. In procedures where SESIPs have been implemented, evaluation of injuries after intervention with safety devices, including use of safety-engineered hypodermic needles, have resulted in dramatic decreases in reports of PIs. (Orenstein, 1995; Clarke, 2002; Slater and Whitby, 2007; Whitby, 2008; Jagger et al., 2010; Valls, 2007) One study reported a 93% reduction in relative risk of PI after implementation of SESIP use. (Valls, 2007) There is also evidence that use of hands-free sharps passing techniques in surgical settings are likely to reduce PIs in the OR by as much as 35% for all surgeries in settings where the practice was used more than 75% of the time. [Stringer et al., 2009(b)] Furthermore, the use of HFT is strongly recommended by OSHA, NIOSH, AORN, practicing surgeons, and the American College of Surgeons (ACS) as a method of minimizing sharps injuries to OR staff. (OSHA CPL, 2001(a); Michaels, 2010; Berguer, 2005; OSHA/NIOSH Bulletin, 2007; ACS, 2007; ACS, 2007)

2.3 OPTIONS OF SESIP HYPODERMIC NEEDLES

Following the promulgation of the OSHA Bloodborne Pathogens Standard (BBP) in 1991, manufacturers of safer medical devices responded by producing various options for sharp medical devices. The initial standard included a requirement for use of safer devices based on “commercial availability” and “feasibility” of use; there was no requirement for employers to periodically reevaluate available devices and opt for selecting better or more protective ones based on changes in commercially available options. The NSPA mandated that OSHA include such a provision in the 2001, updated

BBP Standard. The updated requirements call for employers to document **annually** a review of safer devices. The written exposure control plan must:

> According to section 1910.1030(c)(1)(iv)(A) - Reflect changes in technology that eliminate or reduce exposure to bloodborne pathogens; and
>
> In accordance with section 1910.1030(c)(1)(iv)(B) - Document annually consideration and implementation of appropriate commercially available and effective safer medical devices designed to eliminate or minimize occupational exposure. [OSHA standard, 2001(a)]

Consequently, a noticeable increase in the development of more effective SESIPs, including safer hypodermic needles/syringes, occurred since the passage of the NSPA and update to the OSHA BBP Standard. Figures 2.4 through 2.6 show several available options of safer hypodermic needles.

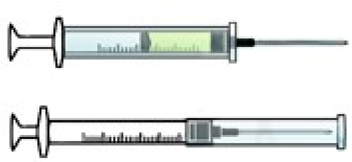

Figure 2.4: Self re-sheathing needles, before and after use. (OSHA website; Hospital eTool)

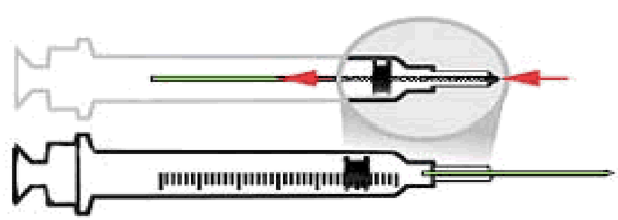

Figure 2.5: Syringe with retractable needles. The used needle retracts into the barrel of the syringe**.** (OSHA website; Hospital eTool)

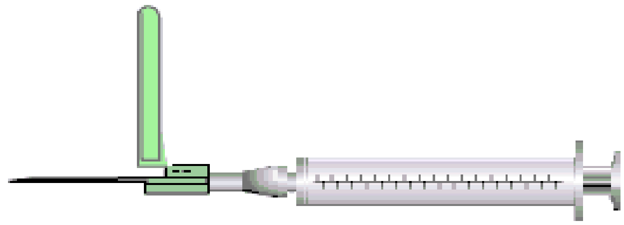

Figure 2.6: Hinged arm safety feature. Hinged arm snaps down to cover needle. (OSHA website; Hospital eTool)

2.4 OTHER IMPLICATIONS OF SHARPS INJURIES

The concerns to healthcare workers go beyond the likely transmission of diseases that may lead to chronic illnesses or death. In addition, there is potential for mental stress and anxiety in affected workers, as well as significant medical costs associated with the management of occupational needlestick injuries. Previous studies have estimated the medical costs associated with post-exposure follow-up, loss of time from work for employees needing medical treatment, lost wages, and the costs associated with the post-exposure prophylaxis (PEP) treatment for employees. One study suggested that "the overall range of costs to manage reported exposures to blood and body fluid was $71 - $4,838," and the "overall mean estimated cost of exposures to HIV infected source patients was $2,456" (O'Malley et al., 2007). This represents an incredible financial concern. A reduction in the burden of injuries will not only greatly improve occupational health among healthcare workers, but will likely also reduce overall costs to healthcare facilities.

2.5 POTENTIAL BARRIERS TO COMPLIANCE AND PREVIOUS RESEARCH

Underlying theories on the potential barriers to safe work practices and use of safety-engineered devices in healthcare have been described in the literature. One recognized barrier to safe work behaviors is the non-compliance with "universal precautions." The Centers for Disease Control and Prevention (CDC) and the Occupational Safety and Health Administration (OSHA) define "universal precautions" as "an approach to infection control, [according to which] all human blood and certain human body fluids are treated as if known to be infectious for HIV, HBV, and other bloodborne pathogens," including HCV (OSHA Standard, 29 CFR 1910.1030). In accordance with this concept, all patients must be treated as if they could be a source of infection and all "exposure incidents" (i.e., blood splashes to mucous membrane, needlesticks, and other PIs) should be promptly reported in order to allow for the opportunity to rule out the employee's exposure to an infectious agent. Several studies have concluded that healthcare workers often do not treat patients with universal precautions and often do not exhibit safe work practices in the administration of healthcare to patients. (Doebbeling et al., 2003; Patterson et al., 1998; Mangione et al., 1991; Gershon et al., 1996; Gershon et al., 1995)

It has been reported that surgeons in training (interns and residents) are less likely to report needlestick injuries if they perceived the risk of infection from the source patient to be low. (Makary et al., 2007) A small study of 42 surgeons in the United Kingdom (UK) found differences in sharps injury reporting and safety precaution behaviors when patients were perceived to be high risk, the injury was considered to be high risk (i.e., higher amounts of blood transferred from the injury), or based on specialty and age of the doctor (younger surgeons were more compliant). (Au, 2008) These results may suggest inconsistent use of "universal precautions" in the surgical setting. These studies did not categorize the strength of the association of these potential drivers of safety-related behaviors. Additionally, it is important to determine whether these factors represent similar drivers of safe work behaviors among OR nurses.

Other studies have highlighted "psychosocial and organizational" factors (Gershon et al., 1995) that contribute to failure of healthcare workers in general to comply with safety protocols or to exhibit safety-related behaviors (e.g., use of universal or standard precautions, reporting of injuries, use of safety-engineered devices, etc.). Researchers in one study reported the following factors as instrumental in determining employees' compliance with universal precautions in healthcare: "1) employee perception of organizational commitment to safety; 2) employee perception of conflicting interest in safety for patient vs. safety for self; 3) employee inclination toward risk-taking; 4) employee perception of risk of particular activity; 5) employee knowledge and training in universal precautions" (Gershon et al., 1995).

In a 2002 study, Sinclair et al. reported results from a telephone-administered survey of 49 hospitals nationwide, conducted prior to the passage of the NSPA. The study assessed perceptions about SESIPs, along with factors associated their use hospital-wide. Although perceptions around use of hypodermic needles was assessed, Sinclair et al. did not distinguish devices used in the OR, nor did the researchers evaluate factors associated with the use of HFT in passing OR instruments. It is widely accepted that the OR represents unique challenges not experienced in other departments in a hospital setting. Therefore, understanding the factors that drive compliance in the OR will better inform interventions that will reduce injuries sustained by members of surgical teams. Several other studies have examined the OR specifically; however, the perceptions of safety assessed in a large proportion of these studies have been limited to a focus on the impact to patient safety, not to worker safety and health. (Makary et al., 2006(a); Makary et al., 2006(b); Mazzocco et al., 2009; Sexton et al., 2006)

Two previous studies have looked at perceptions of OR nurses that affect the individuals' willingness to comply with standard precautions and reporting of needlestick injuries. [Osborne 2003(a); Osborne 2003(b)] These studies were conducted using the Health Belief Model (HBM) among a nursing population in Australia. The HBM has been a commonly used model and its use in assessing individual-level factors associated with compliance with safety measures in healthcare is documented in the literature (Efstathiou, 2011, Powers, 2016). The model includes four original constructs that measure perceptions of susceptibility, severity, barriers, and benefits and was expanded to include others (cues to action and self-efficacy). (Gielen et al., 2006; Efstathiou, 2011) Osborne examined perceptions and attitudes of safety as correlates of compliance with the practice of double-gloving, wearing adequate eye protection, and reporting of needlestick injuries. [Osborne 2003(a); Osborne 2003(b)] Osborne's study used a questionnaire that gathered information on the four original HBM constructs. It was determined that, with regard to PPE use, the perception of barriers to use (specifically, that PPE interfered with one's duties) was the most significant determining factor. [Osborne 2003(a); Osborne 2003(b)] Similarly, Osborne reported that barriers to reporting (i.e., cumbersome reporting processes) were most strongly correlated with compliance with injury reporting. [Osborne 2003(a); Osborne 2003(b)] These studies provide important bases for our research that adds to the literature with inclusion of our results from assessment of the influence of environmental factors on compliance with sharps safety behavior. In our research, the HBM was used in the assessment of individual-level predictors (i.e., predisposing factors).

One other study evaluated the differences in perceptions of risk among OR nurses, in comparison to attending and assistant surgeons, in compliance with universal precautions [Jeong, 2008(a)]. Across all three job categories, results from the study showed an overall low adherence to double-gloving (14%), eye protection use (7%), and use of hands-free technique (1%). [Jeong, 2008(a)] This study used a self-administered survey to collect information within a hospital center in Korea. The study did not evaluate how the relationship between perceptions of risk and compliance varied among different types of hospitals.

Finally, there have been several studies, mostly done in Canada, that have explored the effectiveness of HFT use in OR instrument passing. (Eggleston, 1997; Folin, 2000; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009; Stringer et al., 2010) Stringer et al. have provided the largest body of research in the area of HFT use in operating rooms. Among her findings, Stringer has reported that when HFT was used more than 75% of the time, it was likely to reduce sharps-related injuries by as much as 35%. [Stringer, et al., 2009(b)] It is important to note, however, that in her research, Stringer has determined that the consistent use of HFT (i.e. >75% of the time) was rare; one study found such use occurred for only 42% of surgeries, and another study determined this to be the case in only 35% of surgeries. [Stringer et al., 2002; Stringer et al., 2009(b)] An Australian study found reported rate of regular HFT use to be 72%.

[Osborne 2003(a)] However, the researcher noted the tendency for study participants to overestimate their compliance in self-reported surveys. [Osborne, 2003(a)] While these studies generated important information, the majority of these studies to assess the level of compliance with HFT among surgical staff have been conducted outside the United States. Studies exploring the combined relationships among environmental determinants of compliance with needlestick safety practices along with the individual and collective characteristics among OR nurses in the United States are limited. Therefore, this research was designed to evaluate the constructs integral to the HBM, but also included evaluation of organizational factors that also correlate with safety behaviors of OR nurses. The inclusion of organizational factors will provide additional information that can further guide intervention measures in OR settings across the United States.

2.6 DATA COLLECTION METHODS

2.6.1 Assessment Instrument

The survey was a self-administered, web-based instrument administered via online Survey Monkey™ tool with the intention of collecting data from a sample of nurses and nurse managers who were practicing at the time that the survey was made available. A peri-operative nurse specialist, and the director of membership for the Association of peri-Operative Registered Nurses (AORN) were collaborators on the research project. AORN was excited to collaborate on this study since it supports the long-term efforts of the organization to educate OR nurses and other healthcare workers on the risks from sharps injuries in healthcare settings. The AORN publishes articles and continuously participates in research in this area. With the support of the AORN, participants were invited to participate in the study by email message. A description of the study was provided in the message inviting participants to respond. The questionnaire remained available for 45 days, the customary timeframe for other AORN-administered surveys, in order to provide adequate time for responders to participate. However, all responses were received within the first 30 days that the survey was available.

The survey instrument was a modified version of a previously developed and validated scale (see Appendix B) used in a study that evaluated perceptions that influence compliance with standard precautions and needlestick reporting among OR nurses (Osborne, 2003). Minor modifications were made to the survey questionnaire to adapt the tool to more specifically capture perceptions that correlate with the outcome variables of interest in this study. Some examples of the minor modifications to the survey tool used include removal of questions concerning use of personal protective equipment, an outcome of interest in the Osborne study that was not included in this study. Also, questions were modified to assess perceptions regarding use of HFT and safety-engineered syringes.

2.6.2 Pilot testing

In order to evaluate the appropriateness of the survey instrument for assessing the measures of interest in this study, the questionnaire was pilot-tested prior to dissemination. Pilot testing was conducted with a convenience sample of approximately 10 nurses, six of whom worked at the Johns Hopkins University (JHU) Hospital. The pilot test aided in a) assessing the scales that were used; b) determining the appropriateness of wording of questions; c) informing the final questionnaire; and c) estimating the average time it would take for participants to complete the final questionnaire. The final questionnaire items were tested for internal consistency and reliability using Cronbach's alpha (See Table 4.1). Construct validity of the scales was tested using factor analysis to ensure that the scales developed for this study appropriately represent the selected theoretical model (Champion, 1984).

2.7 SURVEY SAMPLE

The study population was 427 OR nurses from the membership of the Association of peri-Operative Registered Nurses (AORN) from across United States. The AORN has approximately 40,000 members nationwide. Membership includes approximately 10,000 practicing OR staff nurses with various levels of training, approximately 15,000 nurse managers, and members who are non-practicing nurses. Members practice in a variety of different settings (e.g., hospitals or outpatient surgical centers). Eligibility was based on individuals' status as a currently practicing surgical nurse or nurse manager employed in a hospital OR setting or a same-day surgical center. According to information gathered by the Health Resources and Services Administration (HRSA), there were approximately 1,360,847 registered nurses working in hospitals in the United States in 2004. Approximately 13% (176,910) of the hospital nurses were employed in surgical or peri-operative departments. Of these, 32,523 were employed as nurse anesthetists, leaving approximately 144,387 nurses employed in hospital surgical settings who are not considered anesthetists. HRSA also reported an estimate of 575 nurses working in ambulatory surgical settings in that year. It should be noted however that the data from HRSA did not distinguish the proportion of all surgical nurses who were employed in management or teaching positions that could potentially prevent them from being regularly exposed to bloodborne pathogens through involvement in hands-on surgical procedures.

It was important to determine whether information obtained from the survey of this sample population of nurses would be representative of practicing OR nurses nationwide. Attempts were made to assess the demographic characteristics of nurses nationwide (e.g., age, gender, distribution by state or region throughout the country) to estimate the representativeness of the resulting sample. According to a 2014 report using data spanning from 2008 to 2010, HRSA reported that approximately 9.1% of all RNs were male and the remaining 90.9 % were female. The age distribution for all RNs in this same time period was: 23.4% <35years of age: 56.8% 35 to 55 years old; and 19.8% >55years. No report could be found from HRSA estimating the age distribution of RNs working in peri-operative settings. However, according to the AORN, for the OR nurses for whom ages were known, the age distribution slightly differed from that of the HRSA report for all nurses in that the greatest proportion of members were in the age group ≥56 years old (approximately 37.5%), followed by age group 51 to 55 years old (approximately 21.70%), 46 to 50 years old (approximately 14.63%), 41 to 45 years old (approximately 9.18%) and 31 to 40 years old (approximately 12%), and ≤30 years old (approximately 5%) respectively. Ninety-two percent of AORN members are females. It was confirmed with an AORN representative that all members of the organization from which the sample was taken were registered nurses (RNs). After the survey instrument was entered into Survey Monkey™, the link was turned over to AORN's Director of Membership who disseminated it via email to a randomly selected subset of (approximately 5,000) AORN members from across the country. Researchers in the study had no involvement in disseminating the survey beyond the point of providing the link to be emailed. It is uncertain whether every member who was emailed the survey actually received the email. If it were assumed that all intended recipients received the email, then the response rate in this study was approximately 10%.

The study invitation included a small incentive to participate; it included an offer to be entered in a raffle for a free Apple iPad upon completion of the survey. Raffle entries were anonymously submitted after completion of the survey using the email address of an independent party who managed collection of the raffle entries. The prize was awarded after randomizing entries to select a winner. The independent party made contact by email to the winner and only then collected the mailing information so the prize could be awarded. Researchers in the study were not involved in any part of the process of selecting and awarding the Apple iPad winner.

A total of 486 AORN members responded to the survey. Of the total, 481 were currently practicing at the time of the survey. Respondents who dropped out of the study, i.e., those who started but failed to complete all applicable sections, were excluded from analysis. After excluding those who dropped out of the survey, 427 eligible respondents remained. All 427 respondents were included in the analyses of associations between independent variables and HFT use. However, for the purpose of analyzing associations between covariates and SESIP needle use, 14 additional respondents were excluded because they responded "no" when asked whether hypodermic needles (i.e., hollow-bore needles used to inject patients) were used by surgeons in their OR unit. An additional 107 respondents were deemed ineligible because they responded “no” when asked whether safety engineered devices were made available in their OR. Therefore, 306 eligible participants were included in analyses related to the SESIP needle use variable.

The study protocol was submitted to the Johns Hopkins Bloomberg School of Public Health—Institutional Review Board (IRB) and was determined to be exempt from requirements for full IRB approval.

CHAPTER 3. MANUSCRIPT 1

Characterizing safety behaviors among operating room nurses in the United States

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3.1 ABSTRACT

Background – Bloodborne pathogens (BBPs) such as Hepatitis B, Hepatitis C and HIV (Hep B/C/HIV) pose significant occupational health risks to workers in the healthcare industry. The US Department of Labor, Occupational Safety and Health Administration (OSHA) requires use of engineering and work practice controls to eliminate or minimize exposure to bloodborne pathogens. Injuries from needles and other sharp medical devices contaminated with blood are important sources of potential exposure and inoculation to the potentially deadly BBPs. A study published in 2010 reported a 6.5% increase in sharps injuries among operating room (OR) workers across the United States between 1993 and 2006. (Jagger, 2010) During that same time period, sharps injuries decreased by 31.6% in non-surgical settings. (Jagger, 2010)

Objectives – The purpose of this study was to characterize safety behaviors among OR nurses practicing in the United States through evaluation of their work environment and their level of compliance with the use of safety-engineered hollow-bore needles and their practice of hands-free technique while passing contaminated sharps in the OR. The OSHA standard mandates use of safety-engineered sharps injury protections (SESIPs), including safety-engineered needles. The hands-free technique (HFT) is a work practice that eliminates the hand-to-hand passing of contaminated instruments during surgical procedures. The study examined associations between demographic variables and the two safety practices in an effort to inform the wider implementation of these interventions to reduce syringe-related needlesticks in surgical settings.

Methods – We conducted a cross-sectional study of currently practicing operating room nurses. A questionnaire was administered to gather demographic information as well as information regarding safety practices related to sharps used in ORs. Chi square and logistic regression analyses were used to evaluate the associations between the independent variables (e.g., demographic characteristics of respondents, work practices, facility policies, training experiences, etc.) and use of safety engineered hypodermic needles and hands-free passing techniques in the OR.

Results - The reported rates of use of SESIP needles and of HFT were largely infrequent—rates of regular use were reported to be 46% and 42%, respectively. Work practices and policies found to be associated with increased use of SESIP needles and HFT include: the practice of announcing sharps transfers; refraining from recapping used

needles; inclusion in decision of SESIP selection; facilities' mandatory policies for use of SESIP/HFT; and being offered training.

Conclusions – Evaluation of alternatives to repeated uses of hypodermic needles in the administration of local anesthetics, stronger, well-enforced internal policies, and improved training for all members of the surgical team are recommended.

3.2 INTRODUCTION

Injuries from needles and other sharp medical devices that are contaminated with blood and other body fluids present serious occupational health concerns for workers in the healthcare industry. In 1991, the Occupational Safety and Health Administration (OSHA) established regulations, the bloodborne pathogens standard (29 CFR 1910.1030), mandating worker protection through the use of a combination of methods, including engineering controls, work practice controls, personal protective equipment (PPE), and employee education and training. Those regulations were updated after Congress passed the Needlestick Safety and Prevention Act (NSPA) of 2000, which compelled OSHA in 2001 to clarify the need for healthcare workers to be protected through the utilization of "safety-engineered sharps injury protections (SESIPs)" and the need to enact additional requirements to ensure better protection of healthcare workers. A few important new mandates included in the updated OSHA regulations were the requirements for healthcare settings to: a) evaluate newer SESIP devices on an annual basis; b) include non-managerial employees in the selection of safer devices; c) select SESIP devices that are more effective and document reasons for not doing so in the facility's written exposure control plan; and d) maintain a sharps injury log to record percutaneous injuries from contaminated sharps. Under the OSHA standard, the term

SESIP means a non-needle sharp or a needle device used for withdrawing body fluids, accessing a vein or artery, or administering medications or other fluids with a built-in safety feature or mechanism that effectively reduces the risk of an exposure incident [OSHA standard, 2001(a)].

In 2010, ten years after passage of the NSPA, a study using the Exposure Prevention Information Network (EPINet) data reported that while percutaneous injuries (PIs) in nonsurgical hospital settings had decreased by approximately 31.6% over the period from 1993 through 2006, an opposing trend existed regarding PIs among workers in surgical settings, with a reported increase of 6.5% over the same time period. (Jagger et al., 2010) Research has shown that the three instruments reported to be most commonly associated with PIs in the operating room are suture needles (43.4%), scalpels (17%), and syringes (12%). (Jagger et al., 2010; MDPH, 2008)

Engineering controls are considered the primary means of protection, followed by safer work practices and, as a tertiary means of control, personal protective equipment (PPE). Hypodermic needles, disposable syringes with varying gauges (diameter sizes) of hollow-bore, are used in the operating rooms (ORs) by surgical staff. Physicians frequently use hypodermic needles—often times to administer local anesthetics. In some cases, these injections are made in incremental doses. This type of use increases the risk of sharps injuries because of the repeated handling and reuse of the contaminated hypodermic needle between doses. Safer hollow-bore needles, which are sharps with engineered sharp-injury protections (SESIPs), are engineering controls that are widely and successfully used in non-surgical medical practices and are believed to be potentially of equal use if adopted in surgical settings. (Valls, 2007; Jagger et al., 2010; MDPH,

2008) However, such SESIP needles are not as commonly used in operating rooms (ORs). Also, the hands-free technique (HFT) is a work practice that eliminates the hand-to-hand passing of contaminated instruments during surgical procedures, and it has been shown to be successful in reducing sharps injuries when used regularly [Folin, 2000; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b)]. The HFT allows surgical staff to create a designated “neutral zone” or safe area where sharps and other surgical equipment can be placed during a procedure to avoid transferring equipment directly from hand-to-hand. (Stringer et al., 2002) There is evidence from Stringer’s studies done mainly in Canada showing that the use of HFT in surgical settings is likely to reduce PIs in the OR by as much as 35% for all surgeries in settings where the practice was used more than 75% of the time [Stringer et al., 2009(b)].

It is widely accepted that the OR represents unique challenges not experienced in other hospital departments. The purpose of this study was to describe characteristics of the safety behaviors of OR nurses in the United States through evaluation of their work environment and the level of compliance with the use of safety-engineered hollow-bore needles (SESIP needles) and their practice of hands-free technique (HFT) while passing contaminated sharps.

The study protocol was submitted to the Johns Hopkins Bloomberg School of Public Health—Institutional Review Board (IRB) and was determined to be exempt from requirements for full IRB approval.

3.3 METHODS

3.3.1 Research Design

A cross-sectional study was used to evaluate various characteristics (e.g., demographic characteristics of respondents, work practices, facility policies, training experiences, etc.) associated with the use of safety-engineered hollow-bore needles and the practice of hands-free technique while passing contaminated sharps in a sample of members of the Association of peri-Operative Registered Nurses (AORN). In this study, we assumed a positive response for using SESIP also meant activating the safety feature, as appropriate.

The study examined several new requirements set by OSHA in its 2001 update to the standard, such as requirements regarding how SESIP devices are selected and the varying levels of solicitation of input from non-managerial workers in ORs across the United States.

Data were collected in 2012 using a self-administered, web-based survey instrument administered via the online Survey Monkey™ tool. The survey instrument (see Appendix B) was a modified version of a previously developed and validated scale used in an Australian study that evaluated perceptions that influence compliance with standard precautions and needlestick reporting among OR nurses [Osborne 2003(b)]. Minor modifications were made to the survey questionnaire to more specifically capture variables of interest in this study. The survey tool was pilot-tested by 10 nurses prior to use, six of whom were perioperative nurses who worked at the Johns Hopkins University (JHU) Hospital. Questions were further modified based on feedback from the pilot test.

3.3.2 Study Population

The survey was administered to operating room nurses from across the United States, all of whom were members of the Association of peri-Operative Registered Nurses (AORN). Members of AORN practice in a variety of different settings (e.g., hospitals or outpatient surgical centers). The survey instrument was distributed to a randomly selected subset of the association's membership to obtain a sample for the evaluation. The AORN emailed a link to the survey, along with a note of approval.

Eligibility was restricted to nurses and nurse managers who were currently practicing at the time that the survey was made available (i.e., they were employed in a hospital OR setting or other facility such as a same-day surgical center). Of the 486 AORN members who responded to the survey, 481 were currently practicing at the time of the survey. Respondents who dropped out of the study (i.e., those who started but failed to complete all applicable sections, n=54) were excluded from analysis. After excluding those who dropped out of the survey and those not practicing, 427 eligible respondents remained and were included in the analyses used to characterize associations between independent variables and reported use of HFT. However, for the purpose of analyzing associations between independent variables and SESIP needle use, we considered two additional factors. Responders to the survey were asked whether the surgeons in their OR used hypodermic needles, and they were also asked whether any safety-engineered devices were made available in their OR. Those who had no exposure to hypodermic needles (n=14) were excluded and an additional 107 respondents were deemed ineligible because they responded 'no' to the question that asked whether any safety-engineered devices were made available in their OR. Thus, 306 eligible participants were included in the analyses related to SESIP needle use.

3.3.3 Dependent and Independent Variables

The dependent variables were two specific sharps safety-related actions, i.e., the use of syringes with safety-engineered hypodermic (SESIP) needles, and the practice of HFT in passing contaminated sharps in the OR. The two questions used to collect information on the use of SESIP needles and HFT were: 1) *When hypodermic needles are used by surgeons in your OR unit, what proportion of the time are safety-engineered needles used?*; and 2) *When passing sharp instruments (e.g., needles, scalpels, saws, etc.) in my OR unit, I use hands-free passing technique.* A five-point frequency scale ranging from "always" to "never" was used for measuring each dependent variable. Therefore, dependent variables were categorical, and non-parametric testing was used for the analyses.

The independent variables in this study were a combination of individual-level characteristics, safety-related experiences, and characteristics of the respondents' work environments. Demographic and work-related information—such as age, current job title, length-of-time in current job, the size and type of workplace setting, geographic location of the workplace, safety policies/practices, and training experience(s)—were requested. Demographic variables were collected using a combination of continuous and categorical response variables. Facility size, for example, was defined as very small (1-5 ORs), small (6-10 ORs), medium (11-20 ORs), and large (>20 ORs). Job titles were requested in categories similar to ones in which the majority of AORN members identified. However, job titles were also examined using a dichotomized variable that was based on whether the respondent would be expected to be a frequent or infrequent user of sharps in normal work. Thus, a dichotomous variable representing frequency of sharps-use was created by grouping respondents who identified in job titles such as hospital administrators/directors/vice presidents/educators, etc. as expected "low-frequency users" of sharps, while those who identified themselves as staff nurses/clinical nurse specialists/first assistants/team leaders, etc. were regarded as expected "high-frequency users" of sharps. The categories were based on discussions with practicing nurses. See Appendix B for the survey tool used for collecting the data used in this study.

3.3.4 Training Variables

Information was collected to examine whether facilities offered various types of sharps safety training, as required by OSHA. Training experiences were examined with a total of six questions. One question asked whether employers provided training on how to use newly selected safety-engineered sharps; it was measured using a Likert-type item with responses on a five-point frequency scale ranging from "always" to "never." Five other training-related items that were included in the survey asked whether employers trained the OR nurses on: the OSHA requirements; the facility's sharps safety policy; the risks associated with sharps injuries; how to use SESIP needles specifically; and how to use HFT. All of these questions provided "yes-no-I don't know" response options.

3.3.5 Analyses

Responses from the study participants were downloaded from Survey Monkey™ into an Excel spreadsheet and then transferred into Stata 12 statistical packaging for exploratory analysis (StataCorp LP, College Station, TX). After conducting univariate analyses to examine the distributions of each variable, initial evaluations were done by using chi-square (X^2) tests to assess the association of demographic characteristics and reported compliance with use of SESIP needles and with use of HFT in passing of surgical instruments. In order to assess the distributions of the covariates among participants who practiced the safety behaviors of interest (i.e., use of SESIP needles or HFT), we collapsed the five ordinal responses for SESIP needle use and for HFT use. In so doing, each dependent variable was dichotomized as: "SESIP needle (or HFT) users," inclusive of participants who reported "always" or "usually" using SESIP needles (or HFT); and the "SESIP needle (or HFT) nonusers" category, which was inclusive of participants who reported using SESIP needles (or HFT) "about half-the-time," "seldom," or "never." A separate analysis was done to compare characteristics (e.g., demographics, training experiences, work practices, use of HFT, etc.) among the respondents who reported having safety-engineered devices available to them with those who reported having no access to safety-engineered devices in their OR. Additionally, the differences in levels of compliance among respondents based on the type of facility in which they worked were also examined as a way of informing recommendations for facility-level interventions. Where frequencies on the contingency tables were extremely low (<5), Fisher's exact tests were done. Logistic regression was used to simultaneously adjust for demographic predictors associated with the outcome variables.

3.4 RESULTS

3.4.1 Distribution of Demographic and Work-Related Variables

Table 3.1 shows the distribution of demographic and work-related variables, as well as the association between each covariate and each of the two outcomes of interest (i.e., use of SESIP needles and of HFT). Responses were received from OR nurses working in various types of surgical settings across the country. Most responders worked full time (approximately 86%) in a hospital setting (approximately 80%), and the vast majority reported working in small facilities (i.e., <10 ORs). The distribution of nurse responders from different regions was as follows: New England (7.26%), the Mid-Atlantic states (17.33%), the Midwest (23.19%), the South (32.55%), and the Rockies/Pacific/U.S. Territories (19.67%).

Participants in this study were fairly representative of the population of AORN membership with respect to gender, age, and job titles. Study participant distribution by gender was similar to that of the AORN membership (which consists of approximately 8% males) with approximately 9% of all respondents being males. The median age category of respondents, which matched that of the AORN membership, was 51 to 55 years old. Distribution of age ranges for this study's participants alongside the distribution of AORN members for whom ages were known are as follows, i.e., proportion of study participants (proportion in AORN): Approximately 31% of the study population was ≥56 years old (compared with 37.5% in AORN); 51 to 55 year olds made up approximately 23% of the study population (compared with 21.70% in AORN); 46 to 50 year olds were approximately 14.29% of the study population (14.63% in AORN); 41 to 45 year olds were approximately 11.71% of the study population (9.18% in AORN);

31 to 40 year olds was approximately 15% of the study (12% in AORN): and the ≤30 year old age group was approximately 5% of the study population (also 5% in AORN). Team leaders/first line supervisors (26.46%), staff nurses (46.37%), and clinical nurse specialists/RN first assistants (11.01%) together accounted for approximately 84% of all the study respondents; the remaining 16% were upper level managers, directors/VPs/ administrators/educators. Excluding job titles not present in our population, when AORN members' job titles were similarly collapsed into two composite groups representing staff nurse/first line supervisors versus directors/VPs/facility administrators/educators, the distribution by titles was consistent with ours. This information is also presented in Table Appendix D 1.

The surgical units where study participants reported working were: general surgery (33.49%), orthopedics (27.17%), cardiothoracic/obstetrics (6.09%), neurology/ ophthalmology/otolaryngology (9.84%), and other (23.42%). The median timeframe worked on their current job (at the time of the survey) was reported to range from 13 to 60 months (36.77%). This information is not available for the AORN membership.

3.4.2 Overall Reported Use of Hands-Free Technique (HFT) and SESIP Needles

Of the 427 nurses who were eligible for inclusion in analyses related to HFT use, only 180 respondents (approximately 42%) identified themselves as regular ("always" or "usually") HFT users. Although OSHA requires employers to assure the use of engineering controls that are feasible and commercially available for use, of the 306 participants eligible for analyses relating to SESIP needle use, less than half (approximately 46%) reported either "usually" or "always" using SESIP needles. The breakdowns by levels of reported frequency of use are included in Table 3.2 and illustrated in Figures 3.1a and 3.1b.

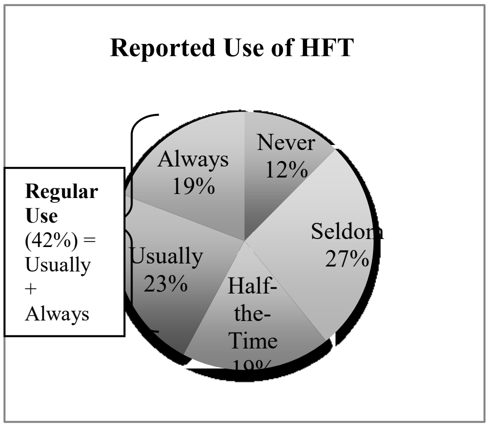


Figure 3.1a: Levels of reported use of HFT. Results reported in Table 3.2

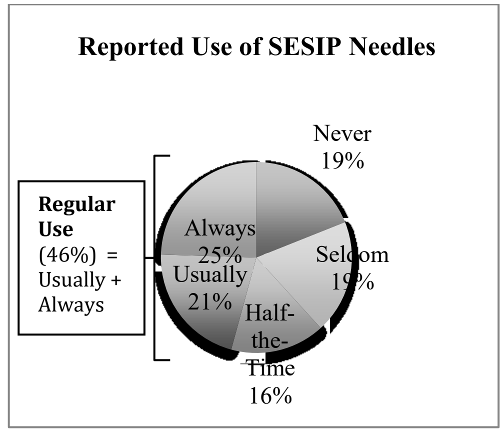


Figure 3.1b: Levels of reported use of SESIP needles. Results reported in Table 3.2

For the subgroup that stated they had SESIPs available in their ORs, 24% were regular users of both SESIP needles and HFT, and approximately 36% were irregular users (or non-users) of both. Those who reported a higher rate of regular HFT use were also more likely to report regular use of SESIP needles.

3.4.3 Reported Use of HFT and SESIP Needles by Demographic and Work-Related Variables

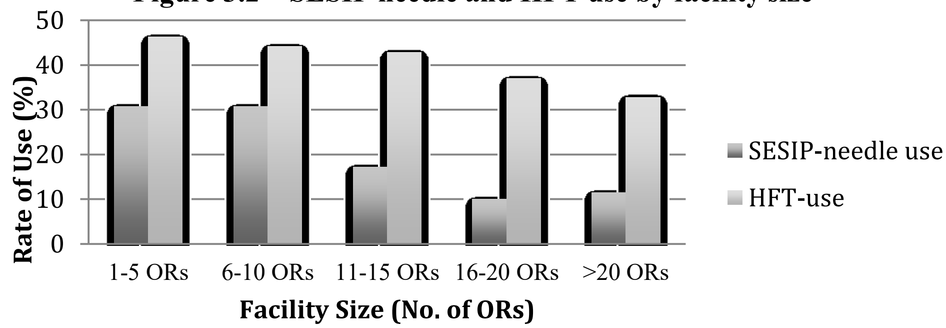
Examination of HFT use by gender and age did not show statistically significant associations at the $p<0.05$ level. (Table 3.1) Although females reported a 44% rate of HFT use, which was almost twice the rate of use reported by males (27%), the small number of males makes it difficult to evaluate true differences by gender. Excluding the seven responders who were age 30 or younger, those in the oldest age group (i.e., ≥56 years old) reported the lowest rates of regular use HFT use (39%), but rates among other age categories were comparable, ranging from 43% to 48%.

Likewise, there was no statistically significant association between either the gender variable or age and SESIP needle use. (Table 3.1) There was, however, a higher rate of SESIP needle use among the small sample of males (52%) than females (45%). The lowest rate of regular SESIP needle use, 20%, was reported by the youngest age category (i.e., those ≤30 years old). However, the numbers of participants in both the male and the younger age groups were very small. A Fisher's exact test was also used to examine the associations between gender and the outcome variables. Results (Table Appendices D 7 and D 8) were not statistically significant.

In terms of job titles and the length of time on the job, both of these covariates showed statistically significant associations with HFT use (Table 3.1). Respondents who worked in the job for ≥20 years had the lowest rate of use of HFT (approximately 27%), while those who were relatively mid-career (i.e., between 5 to10 years on the job) reported the highest rate of HFT use (approximately 49%) (X^2=9.59, 4 degrees of freedom; p=0.048). For job titles, we found a higher reported rate of HFT use among those in managerial titles than among non-managers (X^2=21.01, 4 degrees of freedom; p<0.001). The rates of SESIP needle use were also lowest among those who worked at the job for ≥20 years and among non-managers—however, neither of those associations was statistically significant.

Using chi square analyses, the employment status (i.e., full-time/part-time/per-diem) of responders, as well as the type, size, and geographic region of the nurses' facilities, were all found not to have statistically significant associations with either HFT or SESIP needle use. Fisher's exact tests were also used to examine the associations between the outcome variables and employment status and site type. Results (Table Appendices D 7 and D 8)were not statistically significant. Although chi square analyses of facility size showed no statistically significant association with either HFT use or SESIP needle use, we observed an inverse relationship between the size of the facility and the proportion of nurses who reported use of either safety measure (Figure 3.2).

Figure 3.2 SESIP needle and HFT use by facility size



The OR specialty unit in which participants worked showed statistically significant associations with their reported use of HFT (X^2=10.26, 4 degrees of freedom; p=0.036) and with their use of SESIP needles (X^2=12.64, 4 degrees of freedom; p=0.013). However, assumptions about these findings are limited because, for those who worked in specialties other than "general" or "orthopedic" surgery, reports were either too few or the specialty was within a multidisciplinary category, making it difficult to clearly identify a specific OR unit in which they worked (Table 3.1).

Table 3.1 Distribution of demographic and work-related variables by HFT use (n=427) and SESIP needle use (n= 306[λ])

Demographic Variable	Overall n(%)	HFT nonuser n(%)	HFT user[γ] n(%)	X^2 *(df)* (p-value)	Overall n(%)	SESIP needle nonuser n(%)	SESIP needle user[γ] n(%)	X^2 *(df)* (p-value)
	427 (100%)	247 (57.85%)	180 (42.15%)		306* (100%)	166 (54.25%)	140 (45.75%)	
Age								
≤ 30 years old	21 (4.92)	14 (66.67)	7 (33.33)		15 (4.90)	12 (80.00)	3 (20.00)	
31- 40 years old	64 (14.99)	33 (51.56)	31 (48.44)	2.55 (5)	47 (15.36)	28 (59.57)	19 (40.43)	5.82 *(5)*
41- 45 years old	50 (11.71)	29 (58.00)	21 (42.00)	(p=0.768)	32 (10.46)	16 (50.00)	16 (50.00)	(p=0.324)
46 - 50 years old	61 (14.29)	34 (55.74)	27 (44.26)		50 (16.34)	28 (56.00)	22 (44.00)	
51 - 55 years old	99 (23.19)	56 (56.57)	43 (43.43)		67 (21.90)	35 (52.24)	32 (47.76)	
≥56 years or older	132 (30.91)	81 (61.36)	51 (38.64)		95 (31.05)	47 (49.47)	48 (50.53)	
Gender								
Male	37 (8.67)	27 (72.97)	10 (27.03)	3.80 *(1)*	27 (8.82)	13 (48.15)	14 (51.85)	0.44 *(1)*
Female	390 (91.33)	220 (56.41)	170 (43.59)	(p=0.051)	279 (91.18)	153 (54.84)	126 (45.16)	(p=0.505)
Job title								
Hosp/Facil Admin/ Dir/VP/Ast. Dir	50 (11.71)	14 (28.00)	36 (72.00)		35 (11.44)	14 (40.00)	21 (60.00)	
Nurse Mgr/Supv/Coord/Team Leadr	113 (26.46)	72 (63.72)	41 (36.28)	**21.01** *(4)*	86 (28.10)	43 (50.00)	43 (50.00)	9.18 *(4)*
Staff Nurse	198 (46.37)	121 (61.11)	77 (38.89)	**(p<0.001)**	139 (45.42)	79 (56.83)	60 (43.17)	(p=0.057)
Clinical Nurse Specl/RN First Assist	47 (11.01)	29 (61.70)	18 (38.30)		31 (10.13)	23 (74.19)	8 (25.81)	
Educator	19 (4.45)	11 (57.89)	8 (42.11)		15 (4.90)	7 (46.67)	8 (53.33)	
Job title (dichotomized)[#]								
Non-managers	358 (83.84)	222 (62.01)	136 (37.99)	**15.77** *(1)*	256 (83.66)	145 (56.64)	111 (43.36)	3.61 *(1)*
Managers	69 (16.16)	25 (36.23)	44 (63.77)	**(p<0.001)**	50 (16.34)	21 (42.00)	29 (58.00)	(p=0.057)
Time in current job *(in #months)*								
1-12 months	36 (8.43)	21 (58.33)	15 (41.67)		23 (7.52)	12 (52.17)	11 (47.83)	
13-60 months	157 (36.77)	84 (53.50)	73 (46.50)	**9.59** *(4)*	114 (37.25)	61 (53.51)	53 (46.49)	4.59 *(4)*
61-120 months	78 (18.27)	40 (51.28)	38 (48.72)	**(p=0.048)[§]**	61 (19.93)	27 (44.26)	34 (55.74)	(p=0.332)
121-240 months	79 (18.50)	46 (58.23)	33 (41.77)		53 (17.32)	32 (60.38)	21 (39.62)	
>240 months	77 (18.03)	56 (72.73)	21 (27.27)		55 (17.97)	34 (61.82)	21 (38.18)	

[γ] HFT (or SESIP needle) users included those who *Usually* or *Always* used; non-users were those who used HFT (or SESIP needles) *Half-time/Seldom/Never*
[#] Variable was dichotomized (non-managers=more frequent users vs. upper-managers=less frequent users) jobs; first-line supv included among more frequent users based on anecdotal reports.
[λ] SESIP needle n=306; participants did not qualify to use safe needles if hypodermic needles were not used by surgeons in their ORs nor if SESIPs were unavailable
Chi square test. **Bold** text is statistically significant. [§]Significant results: p<0.05)

Table 3.1 Distribution of demographic and work-related variables by HFT use (n=427) and SESIP needle use (n= 306 [λ]) cont.

Demographic Variable	Overall n(%)	HFT nonuser n(%)	HFT user[γ] n(%)	X^2 *(df)* (p-value)	Overall n(%)	SESIP needle **nonuser** n(%)	SESIP needle user[γ] n(%)	X^2 *(df)* (p-value)
	427 (100%)	247 (57.85%)	180 (42.15%)		306* (100%)	166 (54.25%)	140 (45.75%)	
Employment status								
Part-Time	49 (11.48)	34 (69.39)	15 (30.61)	5.38 *(2)*	31 (10.13)	15 (9.04)	16 (11.43)	5.50 *(2)*
Full-Time	368 (86.18)	205 (55.71)	163 (44.29)	(p=0.068)	269 (87.91)	145 (87.35)	124 (88.57)	(p=0.064)
PRN	10 (2.34)	8 (80.00)	2 (20.00)		6 (1.96)	6 (3.61)	0 (0.00)	
Size of facility; # ORs								
1-5 ORs	121 (28.34)	65 (53.72)	56 (46.28)		87 (28.43)	44 (26.51)	43 (30.71)	
6-10 ORs	136 (31.85)	76 (55.88)	60 (44.12)	3.78 *(4)*	99 (32.35)	56 (33.73)	43 (30.71)	4.68 *(4)*
11-15 ORs	63 (14.75)	36 (57.14)	27 (42.86)	(p=0.437)	43 (14.05)	19 (11.45)	24 (17.14)	(p=0.322)
16-20 ORs	46 (10.77)	29 (63.04)	17 (36.96)		31 (10.13)	17 (10.24)	14 (10.00)	
>20 ORs	61 (14.29)	41 (67.21)	20 (32.79)		46 (15.03)	30 (18.07)	16 (11.43)	
Type of Facility								
Private Hospital	171 (40.05)	102 (59.65)	69 (40.35)		126 (41.18)	68 (40.96)	58 (41.43)	0.78 *(3)*
Public Hospital	169 (39.58)	96 (56.80)	73 (43.20)	1.95 *(3)*	121 (39.54)	65 (39.16)	56 (40.00)	(p=0.853)
Outpatient Surgical Center	73 (17.10)	39 (53.42)	34 (46.58)	(p=0.583)	47 (15.36)	25 (15.06)	22 (15.71)	
Doctor's Office/Other	14 (3.28)	10 (71.43)	4 (28.57)		12 (3.92)	8 (4.82)	4 (2.86)	
OR unit worked								
General Surgery	143 (33.49)	79 (31.98)	64 (35.56)		102 (33.33)	62 (37.35)	40 (28.57)	**12.64** *(4)*
Orthopedic Surgery	116 (27.17)	57 (23.08)	59 (32.78)	**10.26** *(4)*	81 (26.47)	33 (19.88)	48 (34.29)	**(p=0.013)**
Cardiothoracic & Obstetrics	26 (6.09)	16 (6.48)	10 (5.56)	**(p=0.036)**[§]	15 (4.90)	5 (3.01)	10 (7.14)	
Neuro/Opthal/Otolaryngology	42 (9.84)	25 (10.12)	17 (9.44)		33 (10.78)	19 (11.45)	14 (10.00)	
Multidisciplinary	100 (23.42)	70 (28.34)	30 (16.67)		75 (24.51)	47 (28.31)	28 (20.00)	
Region of country								
New England	31 (7.26)	20 (64.52)	11 (35.48)		22 (7.19)	11 (6.63)	11 (7.86)	
Mid-Atlantic	74 (17.33)	41 (55.41)	33 (44.59)	6.39 *(4)*	55 (17.97)	37 (22.29)	18 (12.86)	4.69 *(4)*
Midwest	99 (23.19)	64 (64.65)	35 (35.35)	(p=0.172)	65 (21.24)	34 (20.48)	31 (22.14)	(p=0.321)
South	139 (32.55)	70 (50.36)	69 (49.64)		102 (33.33)	53 (31.93)	49 (35.00)	
Rockies/Pacific/Territories	84 (19.67)	52 (61.90)	32 (38.10)		62 (20.26)	31 (18.67)	31 (22.14)	

[γ] HFT (or SESIP needle) users included those who *Usually* or *Always* used; non-users were those who used HFT (or SESIP needle) *Half-time/Seldom/Never*

[#] Variable was dichotomized (non-managers=more frequent users vs. upper-managers=less frequent users) jobs; first-line supv included as more frequent users based on anecdotal reports.

[λ] SESIP needle n=306; participants did not qualify to use safe needles if hypodermic needles were not used by surgeons in their ORs or if SESIPs were unavailable

Chi square test. **Bold** text is statistically significant. [§]Significant results: p<0.05)

3.4.4 Distribution of Work Practices by HFT and SESIP Needle Use

The survey included questions about work practices other than use of HFT or SESIPs when passing sharp instruments during surgical procedures. For example, the nurses were also asked about the proportion of time they announced the transfer before actually passing sharps between surgical team members. Announcing the passing of sharps is considered a positive practice.

Of the 427 responders, approximately 71% reported that they "usually" or "always" announced passing of sharps. Responders who reported that they "always" announced passes of sharps reported the highest rate of reported HFT use (approximately 56%). These results were statistically significant when frequency of announcing sharps transfers was compared to use of HFT (X^2=34.13, 4 degrees of freedom; $p<0.001$) (Table 3.2).

It is desirable for the transfers of all sharps to be announced in the OR, even when engineering controls such as SESIP needles are used. Of the 306 participants whose facilities had SESIPs available, approximately 71% reported regularly ("usually" or "always") announcing sharps transfers. When we examined the rate of SESIP needle use by those who affirmed that they announced passes in their OR, the highest rate of SESIP needle use (approximately 57%) was reported by the 123 nurses who affirmed that they "always" announced passes of sharps. The associations were statistically significant (X^2=11.85, 4 degrees of freedom; $p=0.019$) (Table 3.2). Through use of a three-way contingency table, we compared the reported rates of use for SESIP needles, HFT, and announcing pass simultaneously. We found that approximately 22% of the nurses (n=67) reported regularly ("usually" or "always") using all three practices; 14% (n=44) reported irregular use of all three practices; and, approximately 21% (n=65) reported regularly announcing pass while infrequently using both SESIP needles and HFT.

The recapping of contaminated needles is considered a dangerous work practice and has been prohibited by the OSHA Bloodborne Pathogens Standard since 1991. Of the subset of responders who admitted to use of needles in their OR—i.e., of 413 responders—186 (approximately 45%) reported regularly recapping used needles in their OR (i.e., the combined proportion of those who recapped "always," "usually," or "half-the-time"). We observed the highest rate of HFT use among those who reported "never" recapping used needles; approximately 52% of them used HFT, as compared to only about 37% of the nurses who said they "always" recapped needles. These results were in the expected direction and statistically significant (X^2=13.47, 4 degrees of freedom; p=0.009) (Table 3.2).

Out of the 306 nurses who worked in ORs where hypodermic needles were used and had SESIPs available to them, a regular practice of recapping needles, as defined above, was reported by approximately 44% of the nurses. In this same subgroup, approximately 61% (n=76) of those who "never" recapped affirmed their regular use of SESIP needles. Comparatively, only about 36% (n=26) of the nurses who "always" recapped needles reported being regular SESIP needle users. These associations were statistically significant (X^2=28.21, 4 degrees of freedom; p<0.001) (Table 3.2).

3.4.5 Distribution of Institutional Policy by HFT and SESIP Needle Use

The existence of institutional policies regarding use of HFT and of SESIP needles were investigated through direct questions asking if a respondent's facility had a mandatory policy about using each of the two safety measures. Each question required a "yes/no/I don't know" response, to which only 92 (approximately 22%) of the entire study population (i.e., of all 427 responders) answered "yes" to having a policy on HFT use. The remaining 78% of the study population either said no HFT policy existed (approximately 63%) or did not know whether their facility had one (15%). A statistically significant association was found between having an institutional policy and the reported use of HFT (X^2=68.87, 2 degrees of freedom; $p<0.001$). (Table 3.2) Of the regular (i.e., "usual" or "always") HFT users, 39% affirmed that their facilities had a policy to use HFT.

Looking only at the subgroup that had SESIPs available, out of those 306 participants, 133 (i.e., approximately 43%) affirmed that their facility had an institutional policy requiring use of SESIP needles. It would be expected that all of these would say "yes" to this question, yet, approximately 38% said there was no policy, and 19% did not know if their facilities had one. Associations between awareness of existing mandatory SESIP use policies and the use of SESIP needles were statistically significant (X^2=84.84, 2 degrees of freedom; $p<0.001$) (Table 3.2). Approximately 70% of regular SESIP needle users worked in facilities with mandatory policies. Among this same subgroup, we found that only 17% gave positive responses to having both a mandatory policy for use of HFT as well as a mandatory policy for use of SESIP needles. Approximately 49% had neither.

When choosing a safer medical device for use, OSHA requires that employers solicit the input of non-managerial employees. This study captures information indicative of the level of compliance with this requirement. Approximately 66% of the 306 eligible nurses affirmed that they personally had provided input into the selection of SESIPs. The association with input in safer device selection and use of SESIP needles was shown to be statistically significant (X^2=8.47, 1 degree of freedom; p=0.004). Those who responded positively about providing input in selection of SESIP devices were found to have a higher rate of SESIP needle use (approximately 52%) than those who gave negative responses (34%). (See Table 3.2.)

Since facilities only need to involve a representative sample of their non-managerial employees in the selection of devices, it is reasonable that not all nurses would respond positively to being asked whether they had been involved in the selection of SESIPs. Therefore, it was considered important to inquire as to the nurses' knowledge of such involvement from their peers. About 75% of the 306 responders affirmed that their peers provided input on the selection of devices, and the rate of SESIP needle use was also higher for those who said their peers provided input in selection of safer medical devices compared with those who responded negatively to that question—49% versus 34%, respectively. However, this association was not shown to be statistically significant. The level of compliance with several OSHA requirements is summarized in Table Appendix D 2.

The questionnaire further asked who decides whether to use SESIPs in the OR. The association between who decides about SESIP use and the actual use of SESIP needles was statistically significant (X^2=17.71, 6 degrees of freedom; p=0.007). Only one-fourth reported that the entire surgical team was involved in making the decision whether to use SESIPs (Table 3.2). However, those who said their entire surgical team participated in the decision reported the highest rate of SESIP needle use (rate of use approximately 57%). An equal proportion of the nurses (approximately 18%) reported that either the nurse manager made the decision or that they did not know how the decision was made. Additionally, approximately 15% said the surgeon made the decision on the use of SESIPs in their ORs.

Table 3.2 Distribution of safety practices and facility policies by HFT use (n=427) and by SESIP needle use (n=306 *)

Safety Practice/Policy	Overall n(%)	HFT nonuser n(%)	HFT user$^{\gamma}$ n(%)	X^2 (*df*) (p-value)	Overall n(%)	SESIP needle nonuser n(%)	SESIP needle user$^{\gamma}$ n(%)	X^2 (*df*) (p-value)
	427 (100%)	247 (57.85%)	180 (42.15%)		306* (100%)	166 (54.25%)	140 (45.75%)	
Use hands-free technique, when passing sharps								
Never	53 (12.41)				34 (11.11)	20 (58.82)	14 (41.18)	
Seldom	114 (26.70)	247 (57.85)	180 (42.15)	------------	82 (26.80)	57 (69.51)	25 (30.49)	**14.07** *(4)*
Half the time	80 (18.74)				59 (19.28)	32 (54.24)	27 (45.76)	**(p=0.007)**§
Usually	98 (22.95)				69 (22.55)	30 (43.48)	39 (56.52)	
Always	82 (19.20)				62 (20.26)	27 (43.55)	35 (56.45)	
Use of SESIP hypod needles**								
Never	119 (28.81)	72 (60.50)	47 (39.50)	**14.90***(4)*	58 (18.95)	166 (54.25 %)	140 (45.75%)	------------
Seldom	80 (19.37)	54 (66.50)	26 (32.50)	**(p=0.005)**§	59 (19.28)			
Half the time	61 (14.77)	44 (72.13)	17 (27.87)		49 (16.01)			
Usually	70 (16.76)	33 (47.14)	37 (52.86)		65 (21.24)			
Always	83 (20.10)	40 (48.19)	43 (51.81)		75 (24.51)			
Announce transfers, when passing sharps								
Never	32 (7.49)	22 (68.75)	10 (31.25)		27 (8.82)	18 (66.67)	9 (33.33)	**11.85** *(4)*
Seldom	65 (15.22)	53 (81.54)	12 (18.46)	**34.13** *(4)*	40 (13.07)	27 (67.50)	13 (32.50)	**(p=0.019)**§
Half the time	28 (6.56)	22 (78.57)	6 (21.43)	**(p<0.001)**	22 (7.19)	14 (63.64)	8 (36.36)	
Usually	135 (31.62)	76 (56.30)	59 (43.70)		94 (30.72)	54 (57.45)	40 (42.55)	
Always	167 (39.11)	74 (44.31)	93 (55.69)		123 (40.20)	53 (43.09)	70 (56.91)	
Recapping used needles**								
Always	103 (24.94)	65 (63.11)	38 (36.89)		72 (23.53)	46 (63.89)	26 (36.11)	**28.21** *(4)*
Usually	64 (15.50)	44 (68.75)	20 (31.25)	**13.47** *(4)*	52 (16.99)	39 (75.00)	13 (25.00)	**(p<0.001)**
Half the time	19 (4.60)	14 (73.68)	5 (26.32)	**(p=0.009)**§	12 (3.92)	10 (83.33)	2 (16.67)	
Seldom	67 (16.22)	43 (64.18)	24 (35.82)		46 (15.03)	23 (50.00)	23 (50.00)	
Never	160 (38.74)	77 (48.12)	83 (51.88)		124 (40.52)	48 (38.71)	76 (61.29)	

HFT- (or SESIP needle) users included those who *Usually* or *Always* used; non-users were those who used HFT (or SESIP needle) *Half-time/Seldom/Never*
*n=306; participants did not qualify to use safe needles if hypodermic needles were not used by surgeons in their ORs nor if SESIPs were unavailable
**Does not add up to total due to missing responses
Chi square test. **Bold** text is statistically significant. §Significant results: p<0.05)

Table 3.2 Distribution of safety practices and facility policies by HFT use (n=427) and by SESIP needle use (n= 306*) cont.

Safety Practice/Policy	Overall n(%) 427 (100%)	HFT nonuser n(%) 247 (57.85%)	HFT user$^{\gamma}$ n(%) 180 (42.15%)	X^2 *(df)* p-value	Overall n(%) 306* (100%)	SESIP needle nonuser n(%) 166 (54.25 %)	SESIP needle user$^{\gamma}$ n(%) 140 (45.75%)	X^2 *(df)* p-value
Facility has mandatory policy on use of HFT				**68.87** *(2)*				
No	271 (63.47)	194 (71.59)	77 (28.41)	**(p<0.001)**	------------	------------	------------	------------
Yes	92 (21.55)	21 (22.83)	71 (77.17)					
I don't know	64 (14.99)	32 (50.00)	32 (50.00)					
Facility has mandatory policy on use of SESIPs needles*								**84.84** *(2)*
No	------------	------------	------------	------------	116 (37.91)	98 (84.48)	18 (15.52)	**(p<0.001)**
Yes					133 (43.46)	35 (26.32)	98 (73.68)	
I don't know					57 (18.63)	33 (57.89)	24 (42.11)	
You provide input on selection of SESIPs *								**8.47** *(1)*
No	------------	------------	------------	------------	105 (34.31)	69 (65.71)	36 (34.29)	**(p=0.004)**[§]
Yes					201 (65.69)	97 (48.26)	104 (51.74)	
Peers provide input on selection of SESIPs *								
No	------------	------------	------------	------------	41 (13.40)	27 (65.85)	14 (34.15)	4.20 *(2)*
Yes					228 (74.51)	116 (50.88)	112 (49.12)	(p=0.122)
I don't know					37 (12.09)	23 (62.16)	14 (37.84)	
Who decides whether to use SESIPs *								
Entire surgical team					75 (24.51)	32 (42.67)	43 (57.33)	
Surgeon(s)					45 (14.71)	35 (77.78)	10 (22.22)	**17.71** *(6)*
Nurse Manager	------------	------------	------------	------------	55 (17.97)	25 (45.45)	30 (54.55)	**(p=0.007)**[§]
Safety officer/Inf contl specl					49 (16.01)	25 (51.02)	24 (48.98)	
Scrub Nurse					1 (0.33)	1 (100.00)	0 (0.00)	
I don't know					55 (17.97)	33 (60.00)	22 (40.00)	
Other (please specify)					26 (8.50)	15 (57.69)	11 (42.31)	

HFT (or SESIP needle) users included those who *Usually* or *Always* used; non-users were those who used HFT (or SESIP needle) *Half-time/Seldom/Never*
*n=306; participants did not qualify to use safe needles if hypodermic needles were not used by surgeons in their ORs nor if SESIPs were unavailable
Chi square test. **Bold** text is statistically significant. [§]Significant results: p<0.05).

3.4.6 Training Experiences

Participants were asked if their employers offered training on the following: a) the OSHA requirements relating to sharps safety; b) the risks associated with sharps injuries; c) the facility's policies related to sharps safety; d) instruction each time a new safety-engineered device was selected for use in the OR; e) specific instruction on how to use SESIP needles; and f) instructions on how to use the HFT. Only six responders reported that their employer(s) had not provided any of these types of training. Of those who reported having been offered *any* training at all, the most commonly offered training was instruction on how to use new safety devices that were selected in the OR (approximately 86%), and the least commonly offered was instruction on using HFT (approximately 66%).

Statistically significant results were shown in the bivariate analyses associating regular HFT use with four out of the six types of training experiences examined (Table 3.3). Of those reporting regular HFT use, 76% were trained on OSHA requirements, 81% were trained on the risks of sharps injuries, 79% were trained on the facility's sharp safety policies, and approximately 78% were instructed on how to use HFT.

Higher rates of SESIP needle use were found to be associated with positive responses on training received. Three training experiences resulted in statistically significant associations with SESIP needle use (Table 3.3). The proportion of regular SESIP needle users who received those three types of training are as follows: approximately 93% were regularly trained on how to use newly selected safety devices; 94% were provided specific training on how to use SESIP needles; and 76% received training on how to use HFT.

3.4.7 Multivariate Analyses

Logistic regression was used to identify the demographic predictors most likely to be associated with the outcome variables. Since time-in-job and age were strongly correlated, only time-in-job was used in the multiple logistic regressions. Multivariate analyses for HFT use adjusting for gender, job title, and time-in-job showed statistically significant associations between the outcome of interest with gender (OR = 2.41; 95% CI: 1.11 - 5.24; $p<0.05$) as well as with job title (OR = 2.71; 95% CI: 1.56 – 4.70; $p<0.001$). The reported rate of HFT use for managers was more than twice that of non-managers. Female participants were found to be more likely to use HFT if they were also managers. Although managers also reported more frequent SESIP needle use, no statistically significant results were found in the adjusted multivariate model of demographic variables with SESIP needle use. These results may be related to the decreased power associated with the lower sample size. (See Tables Appendix D 5 and Appendix D 6.)

Table 3.3. Training experiences analyzed by HFT use (n=427) and by SESIP needle use (n= 306 *)

Safety Practice	**Overall** n(%) 427 (100%)	**HFT nonuser** n(%) 247 (57.85%)	**HFT user**$^{\gamma}$ n(%) 180 (42.15%)	X^2 *(df)* (p-value)	**Overall** n(%) 306* (100%)	**SESIP needle nonuser** n(%) 166 (54.25 %)	**SESIP needle user**$^{\gamma}$ n(%) 140 (45.75%)	X^2 *(df)* (p-value)
Received '*Any*' Training**								
No	6 (1.90)	3 (50.00)	3 (50.00)	0.15 *(1)*	6 (1.90)	5 (83.88)	1 (16.67)	2.13 *(1)*
Yes	400 (98.10)	231 (57.75)	169 (42.36)	(p=0.703)	298 (98.10)	159 (53.36)	139 (46.64)	(p=0.145)
Trained on OSHA sharps safety requirements								5.10 *(2)*
No	113 (26.46)	78 (69.03)	35 (30.97)	**13.06** *(2)*	74 (24.18)	48 (64.86)	26 (35.14)	(p=0.078)
Yes	284 (66.51)	147 (51.76)	137 (48.24)	**(p=0.001)**§	210 (68.63)	105 (50.00)	105 (50.00)	
I don't know	30 (7.03)	22 (73.33)	8 (26.67)		22 (7.19)	13 (59.09)	9 (40.91)	
Provided training on risks assoc. w/sharps injury								
No	100 (23.42)	28 (72.00)	28 (28.00)	**15.63** *(2)*	65 (21.24)	65 (64.62)	23 (35.38)	5.39 *(2)*
Yes	303 (70.96)	157 (51.82)	146 (48.18)	**(p<0.001)**	223 (72.88)	223 (50.22)	111 (49.78)	(p=0.068)
I don't know	24 (5.62)	18 (75.00)	6 (25.00)		18 (5.88)	18 (66.67)	6 (33.33)	
Trained on facility's sharps safety policy								
No	110 (25.76)	81 (73.64)	29 (26.36)	**17.87** *(2)*	69 (22.55)	43 (62.32)	26 (37.68)	5.22 *(2)*
Yes	292 (68.38)	149 (51.03)	143 (48.97)	**(p<0.001)**	217 (70.92)	109 (50.23)	108 (49.77)	(p=0.073)
I don't know	25 (5.85)	17 (68.00)	8 (32.00)		20 (6.54)	14 (70.00)	6 (30.00)	
Trained on use of SESIPs needles**								
No	32 (11.07)	16 (50.00)	16 (50.00)	0.83 *(2)*	32 (11.07)	27 (84.38)	5 (15.62)	**21.25** *(2)*
Yes	243 (84.08)	135 (55.56)	108 (44.44)	(p=0.661)	243 (84.08)	111 (45.68)	132 (54.32)	**(p<0.001)**
I don't know	14 (4.84)	9 (64.29)	5 (35.71)		14 (4.84)	11 (78.57)	3 (21.43)	
Provided training on each newly selected SESIP*								
Never	10 (3.27)	10 (100.00)	0 (0.00)	**11.01** *(4)*	10 (3.27)	10 (100.00)	0 (0.00)	**22.51** *(4)*
Seldom	19 (6.21)	9 (47.37)	10 (52.63)	**(p=0.019)**§	19 (6.21)	15 (78.95)	4 (21.05)	**(p<0.001)**
Half the time	18 (5.66)	10 (55.56)	8 (44.44)		18 (5.88)	12 (66.67)	6 (33.33)	
Usually	97 (31.70)	61 (62.89)	36 (37.11)		97 (31.70)	58 (59.79)	39 (40.21)	
Always	162 (52.94)	85 (52.47)	77 (47.53)		162 (52.94)	71 (43.83)	91 (56.17)	
Provided training on hands-free technique				**21.27** *(2)*				
No	134 (31.38)	98 (73.13)	36 (26.87)	**(p<0.001)**	88 (28.76)	59 (67.05)	29 (32.95)	**8.23** *(2)*
Yes	279 (65.34)	139 (49.82)	140 (50.18)		209 (68.30)	103 (49.28)	106 (50.72)	**(p=0.016)**§
I don't know	14 (3.28)	10 (71.43)	4 (28.57)		9 (2.94)	4 (44.44)	5 (55.56)	

HFT (or SESIP needle) users included those who *Usually* or *Always* used; non-users were those who used HFT (or SESIP needle) *Half-time/Seldom/Never*
*SESIP needle n=306; participants did not qualify to use safe needles if hypodermic needles were not used by surgeons in their ORs or if no SESIPs were available
Chi square test. **Bold** text is statistically significant. §Significant results: p<0.05). **Does not add up to total due to missing responses

3.5 DISCUSSION

3.5.1 Summary of Findings

Despite OSHA's mandate that employers assure the use of feasible and commercially available engineering controls and use of good work practices like HFT, the analysis of these data showed that, overall, more than half the participants in this study reported infrequent use of both SESIP needles (54% of the 306 nurses who had access to SESIPs) and HFT (58% of the total study population). Previous studies have noted the tendency for respondents to overestimate their compliance with safety measures on self-reported surveys. (Osborne, 2003; Stringer et al., 2010) Therefore, the actual frequencies of use for HFT and SESIP needles are likely to be lower than observed for these data. Frequent use of SESIP needles (or HFT) was defined in this study as reports of "usually" or "always" using SESIP needles (or HFT). One concern was that only 72% of respondents worked in environments in which SESIPs were available. Of that population, only 46% reported SESIP needle use. Use of HFT in the same population was 43%, as might be expected for a method that requires more active behavior on the nurse's part. A low rate of compliance has been previously documented in other studies [Stringer et al., 2002; Stringer et al., 2009(b); Jeong, 2008(a)]. The results of this study showed that those who reported a higher rate of regular HFT use were also more likely to report regular use of SESIP needles. Because SESIP use depended on SESIP presence, analyses for this practice were restricted to this subgroup.

We observed overall low compliance rates of other variables believed to be associated with worker protection as reflected in OSHA mandates. For example, the proportion of nurses who reported that their facilities had mandatory policies for using

HFT and SESIP needles were 22% and 43%, respectively. Also, positive safety practices such as announcing sharps transfers and avoiding recapping of used needles were performed less than 100% of the time. The exception was with certain types of training for which rates of experiences were relatively high. However, the types of training were not comprehensive. Details of the forms of worker protection are presented below. Although the unit of analysis for this study is the worker, not the institution, results provide a picture of the conditions and safety behavior of the overall OR nurse population.

Our analysis of the reported use of HFT by demographic variables (e.g., age, gender, job title, employment status or time in job) showed that the practice of hands-free passing varied across the strata of each demographic variable. However, in the bivariate analyses, only the reported job title and time in current job were statistically significantly associated with use. The highest rates of HFT use were reported among those who were relatively mid-career (i.e., between five and ten years on the job) and among those who identified in managerial job titles. The extent to which social desirability might have factored in responses for managers is unknown. However, we found the lowest reported rates of both HFT and SESIP needle use among OR nurses who had worked in their jobs for ≥20 years. Associations between the reported use of SESIP needles and those demographic variables were not found to have statistical significance. The study findings do perhaps suggest a need to take a closer look at the quality and format of training given to OR nurses who have been on the job for a very long time. It would be helpful to determine whether workers who have been on the job for more than 20 years are less accustomed to using safety-engineered devices or HFT and are slower to adopt new practices. Facilities should provide and evaluate training according to length-of-time on the job and implement additional training/coaching where the need is identified.

This study showed variability in the use of both SESIP needles and HFT based on work-related variables characteristics such as OR specialty and type, size, or geographic region of the nurses' facilities. However, only the OR specialty unit in which participants worked showed statistically significant associations with their reported use of HFT and SESIP needles. The assumptions about these findings should be used with caution because reports for specialties other than "general" or "orthopedic" surgery were either too few or the responders were within a multidisciplinary category, making it difficult to clearly identify the OR unit in which they worked. Further research is needed to more clearly determine the impact of OR specialty on the use of HFT and SESIP needles and the causes of differences in rates of use within each type.

With regard to work practices other than use of HFT or SESIPs, we found that only 71% of responders reported that they "usually" or "always" announced the passing of sharps. Announcing sharps transfers helps to ensure that surgical staff is aware of the location of the devices at all times. As a strategy for enhancing the prevention of perioperative PIs, it is recommended that surgical team members alert one another whenever sharps are being passed, including in settings in which engineering controls and HFT are being used. (Herring, 2010; AORN 1999) Less than a third of all responders (about 22%) reported regularly using all of the three practices combined. Approximately 14% reported irregular use of all three practices, and 21% reported regularly announcing sharps transfers while irregularly using both SESIP needles and HFT. Regular announcement of sharps transfers in the absence of regular use of either of the other two safety measures is a likely surrogate for OR nurses who perform hand-to-hand passing without the use of safety-engineered needles or a neutral zone—an extremely dangerous practice. These findings underscore those of others that emphasize the need to investigate reasons behind the exercise of poor work practices and the need for developing intervention to increase compliance. (Clarke, 2002; Osborne, 2003(a); AORN, 2006; Stringer et al., 2006; Myers, 2008; Efstathiou, 2011; Powers, 2016) This study further suggests the need for studies examining the rate at which the safer control measures are concurrently used in ORs.

Our analysis of another dangerous work practice, the recapping of used needles, showed that approximately 45% of the study participants reported regularly recapping used needles (i.e., at least half-the-time). We found higher rates of compliance with SESIP needle and HFT use among those who reported that they "never" recapped compared to those who "always" performed this poor work practice. Based on anecdotal evidence, one reason that used needles are continuously recapped is to allow for the administration of incremental doses of local anesthetics. Although it is true that OSHA permits limited use of needle recapping in situations where there are no alternatives, and many years ago the agency identified placement of incremental dosing among the situations that could qualify for this exception, this policy may warrant re-evaluation. [OSHA CPL, 2001(b)] An option that should be encouraged as an alternative to recapping is the use of prefilled, safety-engineered syringes with smaller doses of anesthetics. Prefilled safety needles became more widely available after the revision of OSHA's standard and are a viable option for reducing the risk of PIs from needle recapping. Safety-engineered devices used in conjunction with HFT and announcing transfers optimize safety of OR staff. Safety features on safety-engineered needles must, of course, be activated at the completion of the procedure in order for them to remain effective at reducing sticks.

Analysis shows that those whose employers had knowledge of mandatory policies to use SESIPs (or HFT) reported the highest rate of regular use (i.e., “usually” or “always”) of SESIP needles (or HFT). Findings in this study were consistent with those of other studies showing that facilities with mandatory policies for safety practices have better rates of safer behaviors than ones without such policies. (Stringer et al., 2009; Gershon 1995; Zohar, 2002; Zohar, 2003) Nonetheless, we found that only 17% of responders reported the existence of mandatory policies for both the use of HFT as well as use of SESIP needles, and approximately 49% had neither. Some responders did not know whether their facilities had mandatory policies for the use of either SESIP needles (approximately 19%) or HFT (approximately 15%). This informs us of the need for not only establishing institutional policies but also better education around their existence.

The study adds to the existing literature by examining additional requirements set by OSHA in its 2001 update to the bloodborne pathogens standard. For example, we looked at the varying levels of solicitation of input from non-managerial workers in ORs across the United States. Approximately 66% affirmed that they had provided input in SESIP selection and 75% affirmed that their peers provided such input. The rate of SESIP needle use was significantly higher among those who reported input by themselves. Although not statistically significant, the rate of SESIP needle use was also higher among those who reported input in selection by their peers. More research is needed, however, to determine whether the input provided by non-managerial staff was directly related to the device selection that the employers ultimately made.

Rates of reported use for both HFT and SESIP needles were positively associated with the presence of training. We found statistically significant associations between regular SESIP needle use and the following three training experiences: reports of training on how to use newly selected safety devices; training specific to using SESIP needles; and training on how to use HFT. Additionally, among those offered *any* training at all, instruction on the use of HFT was the least commonly offered. Stringer et al. found that lack of training on HFT among nurses represents a significant barrier to use of HFT. (Stringer et al., 2006) Nonetheless, statistically significant differences were shown in the bivariate analyses associating regular HFT use with four out of six types of training experiences. Findings in this study are consistent with previous studies that show a higher rate of safety practices among those who report higher rates of training. (Ganczak 2007; Stringer et al., 2009(b); Gershon et al., 1995)

OSHA requires an initial and annual re-training of all exposed workers. However, closer examination would be needed to determine effectiveness of training based on the frequency, methodology used (e.g., in-person versus electronic training), and the impact of facility-level variations in the content of annual training.

3.5.2 Limitations of the Study

Because of the relatively small proportion of AORN nurses who responded to this electronic survey, self-selection into the study may be a source of selection bias. It is not possible to compare those who choose to complete the study to those who do not. This form of selection bias is a concern that is common to many studies that rely on web-based methodology. Although eligibility for participation in this study was not based on any set criteria such as previous history of needlesticks, those who had greater concerns or interest in safety factors may have been more likely to respond. However, all AORN members had equal opportunity to respond, and we found the study sample to be similar with regard to the age, gender and job titles of the membership.

The use of a web-based survey distribution has potential limitations, such as accessibility to eligible participants and the possibility that those most apt to respond would be younger than the general population of OR nurses. For the former, since the members receiving the survey all had current email addresses, we considered this as evidence that accessibility was not an issue. For the latter, as stated above, the age distribution of respondents was representative of the AORN membership. The study could, however, be limited in terms of generalizability to the general population of OR nurses if there are differences between those who join AORN and those who do not.

3.5.3 Recommendations for Further Research

A few items are highlighted that warrant further study, such as the need for further evaluation of training, and the need to determine whether the input provided by staff is directly related to the ultimate device selection made by employers. Also, more research is needed to evaluate alternatives to eliminate the risk of PIs from the practice of incremental dosing and repeated use of a single needle. As injuries are reportedly continuing to increase in surgical settings (Jagger et al., 2010), it is possible that re-evaluation is necessary for OSHA's policy allowing recapping of needles for situations where incremental dosing with anesthetics are placed. Also, further study is needed to examine the effects in facilities that have implemented alternative(s) to the recapping of used needles.

Another recommendation for further research arises from our difficulty to identify the type and specific characteristics of the OR settings in which these nurses work. For example, it would be helpful to understand whether the associations seen in this study are similar when examined according to OR specialty. General surgery and orthopedic departments comprised the largest proportion of work settings represented in this study. The question remains whether the same relationships exist for other types of specialties in which risks, such as the amount of body fluids or types of instruments, may differ.

3.6 CONCLUSION

Previous studies have documented the effectiveness of both SESIP needles [Orenstein, 1995; Clarke, 2002; Slater and Whitby, 2007; Whitby, 2008; Valls, 2007; Jagger et al., 2010) and HFT (Folin, 1997; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b)]. Although OSHA requires a combination of engineering controls, good work practices, and employee training, our examination of safety-related behaviors in U.S. ORs indicated that several requirements are inadequately implemented. The percent who had access to SESIP needles (72%) and the reported rates of infrequent use of SESIP needles (54%) and HFT (58%) were serious concerns.

Efforts to develop interventions to increase the use of HFT and SESIP should take into account the primary findings in this study: 1) demographic variables played little significance in the use of SESIP needles; 2) the overall rates of use for SESIP needles and HFT in ORs were low; 3) those who reported working in settings that had mandatory policies for use of HFT or SESIP needles were more likely to report regular use; 4) rate of use for either SESIP needles or HFT was higher when nurses also reported regular use of other safe work practices (e.g., announcing sharps transfers, refraining from needle recapping); 5) those who had the opportunity to provide input into SESIP selection, and who reported that the entire surgical team contributed to the decision, reported higher rates of use; and 6) those who reported certain safety training experiences reported higher rates of HFT or SESIP needle use. Many of these findings are consistent with the findings of previous studies. [Gershon et al., 1999; Clarke, 2002; Osborne, 2003(a); Cunningham, 2007; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b); Jeong, 2008, Hagstrom, 2006; Efstathiou, 2011] In addition, there is a pressing need for approaches to promote compliance of not only individuals, but also of their institutions, with existing regulations.

Supplemental Tables for Manuscript 1 (Taken from Appendix D)

Table Appendix D 1 Demographic characteristics of study population and AORN membership

Demographic variable	Study Sample (%)	AORN Membership (%)
Gender		
Male	9	8
Female	91	92
Age		
≤ 30 years old	5	5
31- 40 years old	14.99	12.00
41- 45 years old	11.71	9.18
46 - 50 years old	14.29	14.63
51 - 55 years old	23.19	21.70
≥56 years or older	30.91	37.5
Job title (dichotomized)		
Non-managers	84	84
Managers	16	16

Table Appendix D 2 Compliance with OSHA requirements

OSHA Requirements (29 CFR 1910.1030)	Compliance Rate
1910.1030(d)(2)(i) – Use of SESIP needles / good work practices	
Use of SESIP needles	46%
Use of HFT	42%
Announce sharps transfer	70%
1910.1030(c) – Facility has mandatory policy	
Awareness of a mandatory policy to use SESIP needles*	43%
Awareness of a mandatory policy to use HFT*	22%
1910.1030(c)(2)(v) – Solicit employee input in SESIP selection	
Providing input in SESIP selection	66%
1910.1030(d)(2)(vii)(A) – Prohibited recapping	
Avoid recapping used needles (*safer* work practice)	55%
1910.1030(g) – Employee Training	
Trained on use of SESIPs	84%
Trained on use of HFT	65%
Trained on: OSHA requirements; risks assoc. w/ injuries; facility policies	69 – 73%

*In an effort to maintain anonymity, an item was used to represent the nurses' "awareness" of a mandatory policy in lieu of actual information about existence of a policy in specific facilities.

Table Appendix D 5 Adjusted logistic regression models of associations between demographics and HFT use (n=427)

Variable	Bivariate Model⁺ OR	95% CI	Multivariate Model (adjusted) OR	95% CI
Gender				
Male	reference		reference	
Female	2.09	(0.98 - 4.43)	**2.41**	**(1.11 – 5.24)**§
Job Title				
Non-managers	reference		reference	
Managers	**2.87**	**(1.68 - 4.91)**§§	**2.71**	**(1.56 – 4.70)**§§
Time-in-job				
1-12 months	reference		reference	
13-60 months	1.22	(0.58 - 2.53)	1.26	(0.59 – 2.72)
61-120 months	1.33	(0.60 – 2.95)	1.38	(0.60 – 3.17)
121-240 months	1.00	(0.45 – 2.23)	1.15	(0.50 – 2.65)
>240 months	0.53	(0.23 – 1.21)	0.59	(0.25 – 1.41)

⁺Crude bivariate logistic regression Multivariate logistic model; includes the use of HFT adjusted for gender, job title and time-in-job **Bold** is significant §Significant results: p<0.05); §§Significant results, p<0.001

Table Appendix D 6 Adjusted logistic regression models of associations between demographics and SESIP needle use (n=306)

Variable	Bivariate Model⁺ OR	95% CI	Multivariate Model (adjusted) OR	95% CI
Gender				
Male	reference		reference	
Female	0.76	(0.35 - 1.69)	0.80	(0.36 – 1.80)
Job Title				
Non-managers	reference		reference	
Managers	1.80	(0.97 - 3.33)	1.69	(0.90 – 3.15)
Time-in-job				
1-12 months	reference		reference	
13-60 months	0.95	(0.39 – 2.32)	0.95	(0.39 – 2.35)
61-120 months	1.37	(0.53 – 3.59)	1.39	(0.53 – 3.66)
121-240 months	0.72	(0.27 – 1.92)	0.74	(0.27 – 1.99)
>240 months	0.67	(0.25 – 1.80)	0.74	(0.28 – 2.00)

⁺Crude bivariate logistic regression Multivariate logistic model; includes the use of SESIP needles adjusted for gender, job title & time-in-job

CHAPTER 4. MANUSCRIPT 2

Influence of perceptions of safety on use of two safety techniques in the operating room

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4.1 ABSTRACT

Background – Bloodborne pathogens (BBP) such as Hepatitis B, Hepatitis C and HIV (Hep B/C/HIV) pose significant occupational health risks to workers in the healthcare industry. Injuries from contaminated needles and other sharp medical devices are important sources of potential exposure and inoculation to the potentially deadly BBPs. A study published in 2010 reported a 6.5% increase in sharps injuries among operating room (OR) workers across the U.S. between 1993 and 2006. (Jagger et al., 2010) During that same time period, sharps injuries decreased by 31.6% in non-surgical settings. The authors attributed much of the successful sharps-injury reduction in non-surgical settings to an increased use of sharps with engineered sharp-injury protections (SESIPs) such as safety-engineered hollow-bore, hypodermic needles. (Jagger et al., 2010) Implementation and use of such SESIPs have lagged in ORs. Researchers have also previously shown the use of hands-free passing technique (HFT), a work practice that eliminates the hand-to-hand passing of contaminated instruments during surgical procedures, to be successful in reducing sharps injuries when used regularly. [Folin, 2000; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b)]

Objectives - The purpose of this study was to evaluate the factors most strongly associated with the use of safety-engineered disposable syringes and hands-free passing technique in operating rooms in order to inform the wider implementation of these interventions to reduce syringe-related needlesticks in surgical settings.

Methods – We conducted a descriptive correlational study of currently practicing operating room nurses. A questionnaire was administered to gather information on factors of a modified PRECEDE behavioral model that included constructs of the Health Belief Model, as well as information about training experiences of OR nurses. Chi square tests were used to examine the observed versus expected frequencies of associations between the nurses' health beliefs, various organizational factors and the use of HFT and SESIP needles in the OR. Multiple logistic models were applied to better identify the individual-level and organizational-level factors that were the strongest independent predictors of SESIP needle and HFT use.

Results – The PRECEDE factors identified as the strongest independent predictors of SESIP needle use were: low perceptions of barriers (e.g., perceived as not interfering with procedures), high views related to enabling factors (e.g., high perception of one's skills in using SESIP needles) and environmental factors (i.e., policy mandating use). Similar findings were identified with HFT use, however an additional construct, high perceptions of benefits to use of HFT, emerged as an independent predictor of HFT use. Training was also a significant predictor of SESIP needle use.

Conclusions - This study supports findings of other studies that show the influence of perceived barriers, enabling factors, existing institutional programs and training on compliance with safety practices. (Stringer et al., 2009[b], Stringer et al., 2011; Osborne, 2003(a); Gershon, 1995) Future studies should identify interventions that are aimed at designing methods of worker education that take into account individual level perceptions and behaviors, such as barriers and enabling factors, and at increasing the existence and awareness of effective mandatory use policies at the institutional level.

4.2 INTRODUCTION

Research has shown that the three instruments reported to be most commonly associated with percutaneous injuries (PIs) in the operating room are suture needles (43.4%), scalpels (17%), and syringes (12%). (Jagger et al., 2010; MDPH, 2008) Needlesticks and other sharps injuries place exposed workers at risk of contracting potentially life-altering diseases like Hepatitis B (Hep B), Hepatitis C (Hep C) or the human immunodeficiency virus (HIV). Federal regulations, set by the Occupational Safety and Health Administration (OSHA) require employers to use available sharps with engineered sharp injury protection (SESIP) and work practices as first line defense against PIs. Some unique challenges exist in the OR that are not experienced in other departments in a hospital setting. However, through previous research, there is evidence that the regular use of a specific work practice called hands-free technique (HFT) can reduce the rate of sharps injuries in the OR. [Folin, 2000; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b)] HFT is a work practice that eliminates the hand-to-hand passing of instruments during surgical procedures by creating a ‘neutral zone’ into which sharp devices are placed for transferring from one team member to another (Stringer et al., 2002). A study by Stringer et al. showed that the use of HFTs in surgical settings are likely to reduce PIs in the OR by as much as 35% for all surgeries in settings where the practice was used more than 75% of the time [Stringer et al., 2009(b)].

In 2010, a study using the Exposure Prevention Information Network (EPINet) data reported that while percutaneous injuries (PIs) in nonsurgical hospital settings had decreased by approximately 31.6% over the period from 1993 through 2006, an opposing trend existed regarding PIs among workers in surgical settings with a reported increase of 6.5% over the same time period (Jagger et al., 2010). The reduction in PIs in nonsurgical settings is due largely to the use of safety-engineered sharps with injury protection, namely safer hypodermic needles and needleless IV systems (Jagger et al., 2010; MDPH, 2008). Disposable syringes with varying gauges (diameter sizes) of hollow-bore, hypodermic needles are used in the operating rooms – physicians often use these devices to inject local anesthetics, and the handling of these sharps often involve repeated manipulations while placing incremental doses on a single patient using the same (contaminated) needle. Safer hypodermic needles (SESIPs needles) are commonly available and can be successfully used to administer anesthetics in the OR. Yet, such SESIP needles are not as commonly used in ORs as they are in non-surgical settings.

Understanding the factors that drive compliance in the OR will better inform intervention measures that will reduce injuries sustained by members of surgical teams.

In two previous studies, researchers looked at perceptions of OR nurses that affect the individuals' willingness to comply with standard precautions and reporting of needlestick injuries using the Health Belief Model (HBM) [Osborne, 2003(a); Osborne, 2003(b)]. The HBM is a commonly used model and its use in assessing individual-level factors associated with compliance with safety measures has been documented in other healthcare-related studies (Efstathiou, 2011, Powers, 2016). The model includes four original constructs that measure perceptions of susceptibility, severity, barriers, and benefits and was expanded to include others (cues to action and self-efficacy). (Gielen et al., 2006; Efstathiou, 2011) Osborne gathered information on the four original HBM constructs and examined perceptions and attitudes of safety as correlates of compliance with the practice of double-gloving, wearing adequate eye protection, and reporting of needlestick injuries [Osborne 2003(a); Osborne 2003(b)]. Those studies provide important bases for this research by offering information related to the role of individual-level predictors of certain safety-related behaviors in the OR, as examined using the HBM. The need to better understand the complex interrelationships of individual-level factors and organizational-level factors in relation to the use of SESIP needles and HFT in the OR was the impetus for this research.

The purpose of this study was to assess the factors associated with the use of safety-engineered disposable syringes in operating rooms in order to inform the implementation of interventions to reduce syringe-related needlesticks in surgical settings. In this study, the factors associated with use of hands-free passing technique among this study population were also examined as a way to identify similarities and/or differences in the factors that lead to each of these two safety-related behaviors. The PRECEDE-PROCEED Behavioral Model, one of the most commonly used behavioral and social sciences theories cited in unintentional injury research (Trifiletti et al., 2005), was used to simultaneously examine individual-level and organizational-level correlates of SESIP needle and HFT use. The PRECEDE portion of the model was modified to include constructs of the HBM as the measures of individual-level perceptions. The specific aims used to guide the research were: 1) to assess the perceptions of practicing OR nurses that are associated with two specific sharps safety-related practices in the OR [i.e., the use of syringes with safety-engineered hypodermic needles, and the use of hands-free technique (HFT) for passing of contaminated sharps]; and 2) to characterize the strength of the association between several contributing factors and the use of the sharps safety-related practices (i.e., the use of syringes with safety-engineered hypodermic needles, and hands-free passing of contaminated sharps).

4.3 METHODS

4.3.1 Research design

The research used a descriptive correlational study design [Gielen 2006, Chapter 8, p. 161; Osborne, 2003(a)]. The descriptive correlational study design is deemed suitable for describing the factors associated with particular safety-related behaviors, and assessing "correlation of theoretical constructs" with the safety-related behaviors of interest (Gielen 2006, Chapter 8, p. 184). Whereas the survey administered in 2003 by

Osborne et al. used the HBM to assess individual-level perceptions and attitudes of Australian OR nurses relative to reported safety-related behaviors to prevent PIs, this research was designed to evaluate the constructs integral to the HBM, but also included evaluation of organizational factors that also correlate with the safety behaviors. To accomplish this, we used a modified version of the PRECEDE behavioral Model as a theoretical framework for assessing correlates of the two safety-related behaviors, use of SESIP needles and HFT. The inclusion of organizational factors provides additional information that can further guide intervention measures in OR settings. (See Appendix A for Theoretical Framework)

4.3.2 Study Population

The study population included operating room (OR) nurses from across the United States (U.S.), all of whom were members of the Association of peri-Operative Registered Nurses (AORN). A survey was distributed by email to a randomly selected subset of the association's membership, and a sample was obtained that was representative of the AORN members nationwide.

A total of 486 nurses responded to the survey. Eligibility was restricted to nurses and nurse managers who were currently practicing at the time that the survey was made available. After excluding 5 nurses who reported they were not currently practicing at the time of the survey and 54 respondents who dropped out of the study before completing it, 427 eligible respondents remained and were included in the analyses of associations between covariates and HFT use. For the purpose of analyzing associations among the covariates and SESIP needle use, 121 additional respondents were excluded (i.e., 14 who denied the use of hypodermic needles to inject patients in their OR units and 107 respondents were deemed ineligible because they denied having safety-engineered devices (SESIPs) of any kind available for use in their ORs.) Thus, 306 eligible participants were included in analyses related to SESIP needle use.

Examination of the responses revealed that the participants used in this study were representative, with respect to key demographic and employment characteristics (e.g., age, gender, job title, time in job and job settings), of the AORN population from which the study participants were drawn. The distribution of demographic variables in the sample population used to analyze the use of HFT (n=427) was very similar to the distribution in the subgroup (n=306) used to analyze the use of SESIP needles. Further, the distribution of the subset of responders who said there were no available safety devices in their ORs was similar, with respect to key demographic and employment characteristics (e.g., age, gender, job title, job settings, etc), to that of the participants who affirmed availability of SESIP devices.

4.3.3 Theoretical Framework

The PRECEDE portion of the PRECEDE-PROCEED Model allows for *"1) social assessment, 2) epidemiological assessment, 3) behavioral and environmental assessment, 4) educational and organizational assessment, and 5) administrative and policy assessment"* (Gielen 2006, Chapter 7, p. 136). According to this model, constructs within the educational and organizational assessment phase (i.e., predisposing factors, reinforcing factors, and enabling factors), along with those in the environmental assessment phase represent direct risk factors for the particular health-related behavior under assessment.

In this research, a modified version of the PRECEDE behavioral model was used—constructs based on the HBM were included as independent variables to assess individual-level predictors (i.e., predisposing factors) and the other constructs in the PRECEDE model (i.e., enabling, reinforcing and environmental) were used in an assessment of effects from environmental or organizational factors on compliance with sharps safety behaviors. Appendix A represents the theoretical model and considerations for measures that were assessed.

4.3.4 Data Collection

A self-administered, web-based survey instrument distributed via online Survey Monkey™ tool was used to collect data. The survey instrument (see Appendix B) was a modified version of a previously developed and validated scale. The scale was initially developed as a tool for assessing the constructs of the HBM. (Champion, 1984) In 2003, the instrument was modified and used to evaluate perceptions that influence compliance with standard precautions and needlestick reporting [Osborne, 2003(b)]. Minor modifications were made to the 2003 survey questionnaire to adapt the tool to more specifically capture correlates of the outcome variables of interest in this study. The survey tool was pilot-tested and, based on feedback from the pilot test research questions, further modified. The internal consistency of the final survey questions was verified using Cronbach's alpha with results comparable to the Osborne study (α ranging from 0.64 to 0.77). (See Table 4.1)

Using the model of the Osborne survey, questions were included for assessing the other PRECEDE factors (i.e., enabling, reinforcing and environmental). For the items grouped in each PRECEDE factor, factor analysis demonstrated that grouped items were measuring the same construct.

The study protocol was submitted to the Johns Hopkins Bloomberg School of Public Health—Institutional Review Board (IRB) and was determined to be exempt from requirements for full IRB approval.

4.3.5 Dependent and Independent Variables

The dependent variables of interest were two specific sharps safety-related behaviors (i.e., the use of syringes with safety-engineered hypodermic needles, and the practice of HFT in passing contaminated sharps) in the OR. A frequency scale was used for measuring each outcome variable. To differentiate between those who were regular users of safety-engineered needles (or HFT) and those who were not, we dichotomized the outcome variables by collapsing the five ordinal responses for each outcome variable. Participants who reported using SESIP needle (or HFT) “always” or “usually” were considered “users”, and participants who reported practicing these behaviors “half-the-time”, “seldom” or “never” were considered “non-users.” This characterization of compliance is similar to that of other researchers’; e.g., Stringer et al. used reported HFT use of 75% and 100% to represent “users” and those reporting 50%, 25% or none as “non-users.” (Stringer et al., 2002)

Independent variables included constructs of the modified PRECEDE framework that represent individual and collective characteristics of OR nurses and environmental factors. Note that constructs associated with HBM model are included as predisposing factors. The final set of variables represented the following: a) ***predisposing factors*** (i.e., demographics such as age, gender, length of time on one's job, etc., constructs of the Health Belief Model, namely, measures of *susceptibility* to injury/illness, perception of the *severity* of possible consequences from work injuries, perceptions of *barriers*, and perceptions of *benefits* of sharps safety practices; b) ***enabling factors*** (e.g., availability of SESIPs and/or HFT, and skills in using SESIPs and/or HFT); c) ***reinforcing factors*** (e.g., use of SESIPs and/or HFT by peers, and use by higher ranking surgical team members); d) ***environmental factors*** (e.g., mandatory policies). Factors associated with ***training*** were also included to determine the potential role of the training experience(s) of the study participants relative to other correlates of SESIP needle (or HFT) use. (See Appendix C – PRECEDE Categorization of Survey Questions.)

Since it was important to look at a range of individual-level and employment characteristics, assessment also included an examination of the associations between outcomes and variables corresponding to the nurses' employment status; their involvement in the selection of SESIP devices; the types or sizes of facilities in which they worked; and, their performance of other safety practices such as the announcement of sharps transfers and avoidance of used needle recapping.

4.3.6 Treatment of the HBM-Derived Constructs (Predisposing Factors)

The HBM constructs used to operationalize the predisposing factors were based on summed responses to items on a five-point Likert scale ranging from "strongly agree" through to "strongly disagree." Final scores for each construct can be interpreted as follows.

Higher scores on the susceptibility scale (three items) were considered to indicate higher perceived levels of susceptibility to illness (i.e., HIV, Hep B or Hep C) from their work. Similarly, the score on the severity scale (three items) was associated with the perception of a higher degree of severity associated with possible consequences (e.g., loss of one's career, loss of financial stability, or adverse effects to a significant other) if they contracted a disease from work. Perceived benefits from use of SESIP needles or HFT were measured using single items for which a higher score indicated a stronger belief that use of the respective protective measure is beneficial to reducing one's risk of injury/illness. Finally, perception of barriers was based on three items for SESIP use and two items for HFT use, which were coded such that higher scores indicated that the responder disagreed that use of SESIP needles (or HFT) interfered with certain procedures in one's operating room or that use of either safety method was too time consuming to regularly practice. To summarize, higher scores for all four variables corresponded to the conditions that would favor the use of the two protective behaviors.

See Table 4.1 for the items used as measures of the HBM constructs.

4.3.7 Treatment of Remaining PRECEDE Factors

Summed variables were also developed for the other PRECEDE constructs. Enabling factors were measured using four Likert-type items for SESIP needle and two Likert-type items for HFT. Higher scores here indicated that the responder felt confident in his/her skill to use the safety method(s); and/or that SESIP needles (or HFT equipment) were not limited either in supply or based on cost.

Reinforcing factors were measured using a total of six Likert-type items. Higher scale scores suggested stronger views that a participant's use of SESIP needles (or HFT) would be likely to increase if: their peers or a senior team member used it; or they were aware the patient was infected with Hep B/C or HIV; or use would likely decrease in an emergency situation.

For each outcome variable, it was determined that the environmental factor would be measured using a single item that asked about the existence of an institutional policy for use of SESIP needles or HFT. The item was dichotomous (yes/no) format (scored zero or one, respectively). Again, a higher score represented stronger views that awareness of a mandatory policy positively influenced use of SESIP needles or HFT.

See Table 4.2 for the items used as measures of enabling, reinforcing and environmental factors.

4.3.8 Training Experiences

Six separate questions described training experiences—one Likert-type item with responses on a frequency scale ranging from "always" to "never," and five items with responses of "yes-no-I don't know" (Y/N/IDK). The training variables were dichotomized as low or high scores, with the Likert-type item dichotomized using "never," "seldom," or "half-the-time" responses as low (no) and using "usually" or "always" as high (yes). The Y/N/IDK responses were dichotomized to regard "I don't know" responses as negative and were included as low scores along with "no." The dichotomous versions of the training variables were used in subsequent logistic regression analyses with the outcomes SESIP needle (or HFT) use.

4.3.9 Treatment of Missing Data

Several skip patterns were inserted in the questionnaire to move respondents past questions that were not applicable based on their sharps-handling experiences. Careful evaluations were made of responses and the patterns of skipped questions. Determination was made based on whether or not the missing responses appeared missing at random, in which case they were not expected to affect the interpretation of the data and median values were substituted for randomly missing responses. Where there were apparently deliberate missing responses, e.g., ones related to questions associated with a pre-determined skip pattern, those participants were not included in the related analyses.

4.3.10 Analyses

Data were analyzed using Stata 12 statistical package (StataCorp LP, College Station, TX). Initial analyses were done by assessing the reported levels of compliance with the outcome variables among nurses. Chi-square (X^2) tests were used to assess the association between demographic characteristics, work-related policies and training experiences and compliance with each outcome variable (use of SESIP needle and HFT).

Each variable represented in the modified PRECEDE model was assessed by descriptive statistics for each individual item and then for summed construct values (i.e., HBM constructs, enabling, reinforcing, and environmental factors). Table 4.3 shows the ranges and median scores for each summated construct. Each summed variable was further dichotomized according to its median as “high” (including median) or “low” score. Because the environmental factor was measured using a single dichotomized variable, for this factor, the “no” responses represented “low” scores and the “yes” responses represented “high” scores. The final models were assessed using the dichotomized construct variables.

Bivariate logistic regression analyses examined the crude associations of each demographic covariate, each of the dichotomized construct variables, and the dichotomized training variables with outcome variables. Multivariate logistic regression analyses models were built by first testing associations between all dichotomized PRECEDE factors and the outcome measures—i.e., in a model containing the HBM scales as well as the enabling, reinforcing, and environmental factors. In a stepwise manner, other covariates that showed significance in the bivariate analyses (i.e., job title, time in current job, type of OR specialty, training items) as well as key demographic characteristics (i.e., age and gender) were added to the model. Likelihood ratio tests were used to compare results of successive multivariate models and to determine whether a larger model was supported over a more restricted model (i.e., one with fewer covariates). Additional post-estimation tests for the final adjusted multivariate models were done using the Wald and Hosmer-Lemeshow’s goodness-of-fit tests. The results of post-estimation analyses using the Wald test were supportive of the final models—results for the SESIP and HFT use models showed statistical significance, indicating the included covariates improved the fit of the models (X^2=73.34, [df=10], $p<0.001$ and X^2=80.37, [df=9], $p<0.001$, respectively) Post-estimation analyses using Hosmer-Lemeshow goodness of fit test were also supportive of the final, fully adjusted multivariate models—estimated results were X^2=10.84, [df=8], p=0.21 and X^2=2.85, [df=8], p=0.94 for the SESIP and HFT use models, respectively. A low p-value on this test would have been indicative of a poor fit.

4.4 RESULTS

4.4.1 Demographic Variables

The most frequent groups of responders according to gender, position, and employment status were females, non-managers, and nurses who were employed full-time. With regard to age, more than half were over the age of 50. Job title, time in one's job, and the OR specialty unit in which one worked were significantly associated with use of HFT. However, other than OR specialty, no association between demographic variables and SESIP needle use was shown to be statistically significant. With regard to age, the youngest and oldest groups were least likely to use HFT, but the oldest age group was most likely to use SESIPs. Those with more than 20 years of service in their current position were less likely to use either HFT or SESIP needles, compared to those with shorter tenure. (See Table 4.4)

4.4.2 Construct Scores

Table 4.3 shows the distribution of scores for each summed PRECEDE construct for each outcome. As mentioned above, each summed variable was further dichotomized according to its median as high (including median) or low score. For the environmental factor, which represented the awareness of an existing institutional policy, responses more frequently showed low awareness of existing SESIP or HFT policies.

4.4.3 Relationships of Safety-Related Practices, Institutional Policies, and Training

Less than 50% of the nurses in the study reported regular compliance with either of the outcomes (i.e., SESIP needle use or HFT use). When responses concerning other sharps-safety practices were evaluated, that with which the nurses most frequently complied was announcing transfers of surgical equipment (71%). Approximately 57% of responders acknowledged no awareness of a policy to use SESIP needles and 78% gave responses that they were unaware of a policy in their facility to use HFT. (See Table 4.5)

Using the dichotomized training variables, every measure of nurses' training experiences was associated with their reported use of SESIP needles (X^2 range from 4.48 to 13.40 [df = 1], $p < 0.001$ to $p = 0.028$) and HFT (X^2 range from 12.88 to 21.26 [df = 1], $p < 0.001$). These included training on: the use of HFT and SESIPs; OSHA requirements; risks associated with OR sharps injuries; and the facility's sharps safety policies. (See Tables 4.6 and 4.7.)

4.4.4 Logistic Regression Models of PRECEDE Constructs

i. Bivariate Logistic Regression Results

In bivariate models, with the exception of reinforcing factors, the associations between PRECEDE constructs (i.e., "low" versus "high") and the use of SESIP needles (or HFT) were in the expected direction. (See Table 4.8.) We found the following: nurses who reported "low" perceived barriers (i.e., high level of <u>disagreement</u> that using SESIP needles was either an interference or inconvenient) were more than twice as likely to use SESIP needles (OR = 2.42; 95% CI: 1.53-3.85; $p < 0.001$)—that is, perceived lack of barriers was associated with increased use of protective devices. Those reporting "high" enabling scores were more than eight times as likely to use SESIP needles (OR = 8.21; 95% CI: 5.26-12.8; $p < 0.05$); and those who reported knowledge of the existence of institutional policy were almost nine times more likely to use SESIP needles (OR = 8.73; 95% CI: 5.20-14.68; $p < 0.001$). (See Table 4.8.)

The same factors (lower perception of barriers, high scores on enabling, and environment scales) were associated with the use of HFT (OR = 3.55; 95% CI: 2.33-5.41; $p < 0.001$; OR = 3.17; 95% CI: 2.08-4.83; $p < 0.001$ and OR = 7.01; 95% CI: 4.09-12.00; $p < 0.001$, respectively). Additionally, reports of "high" benefit scores were almost four times as likely for those using HFT (OR = 3.82; 95% CI: 1.98-7.40; $p < 0.001$) (See Table 4.8.)

ii. Multivariate Logistic Regression Results

We developed multiple logistic regression models by first entering the four PRECEDE constructs (predisposing, enabling, reinforcing, environment) only. (See Tables 4.9 and 4.10.) Then, fully adjusted models were developed to examine the associations of the PRECEDE constructs with use of SESIP needles (or HFT) while controlling for effects of other independent variables. (See Tables 4.9 and 4.10.) This was done by adding the variables that were significant in bivariate analyses (i.e., job title, time in current job, type of OR specialty, training items) and key demographic characteristics (i.e., age and gender) one by one to a multivariate model containing all four PRECEDE factors. A covariate was retained if, based on the results of the likelihood ratio tests, it improved the log likelihood.

When the SESIP needle use model was adjusted for other PRECEDE constructs, the same statistically significant associations remained as for bivariate analyses, with the exception of the barriers variable which did not result in a statistically significant association in this model. The same pattern existed for the HFT use model, which also controlled for other PRECEDE constructs; i.e., the same four constructs identified in the bivariate analyses (low perceived barriers, high perceived benefits, enabling, and environmental factors) were associated with more frequent HFT use. However, in the case of both protective behaviors, odds ratios for independent variables became slightly attenuated. (See Table 4.9 and Table 4.10)

In the final, fully adjusted multivariate models, the PRECEDE constructs that demonstrated statistically significant associations with each outcome variable in the unadjusted models remained significant though not all as equally strong. After adjusting for job title and SESIP-related training, the direct effects of the barrier constructs, enabling factors, environmental factors and training on how to use SESIP needles resulted in significant associations with SESIP needle use. Odds ratios, confidence intervals, and p-values are presented in Table 4.9.

In the final adjusted model of associations between independent variables and HFT use, after adjusting for one's job title and HFT training, the direct effects of the following constructs and independent covariates persisted in demonstrating significant associations with the nurses' use of HFT: measures of barriers and benefits; enabling and environmental factors; and job title. Odds ratios, confidence intervals, and p-values resulting from this model are presented in Table 4.10.

4.5 DISCUSSION

The desire for a better understanding of the complex interrelationships of individual-level factors and organizational factors in relation to the use of SESIP needles and hands-free passing of instruments in the OR was the motivating factor behind this research. To assess these, we constructed a model that incorporated a novel use of a modified PRECEDE behavioral model that included HBM constructs. Our approach was similar to a study of OR nurses in Australia that used the HBM constructs to examine factors associated with OR nurses' performance of standard precautions, particularly their use of personal protective equipment [Osborne, 2003(b)]. Based on that approach, we adapted scales to represent the constructs of the PRECEDE model as a means of identifying factors associated with SESIP and HFT use. In our modification, one construct that is typically included in the PRECEDE model, predisposing factors, was broken down to be represented by the factors used in the Health Behavior Model—susceptibility, severity, barriers, and benefits. The adapted scales when made specific to the use of SESIP needles or HFT were shown to be of equivalent reliability in comparison to those used in other studies of other safety behaviors.

In general, we found that greater proportions of users of SESIP needles (and of HFT) reported scores on the modified PRECEDE constructs that were in the direction that would be expected with safer behaviors. We also found that these two safety behaviors correlated with other measures of safety practices (i.e., announcing sharps transfers and avoiding recapping of used needles). More than half those who perform either of the other two safe work practices also reported use of SESIP needles (or HFT). This was not surprising but, as the first study to use this modified PRECEDE model as a framework for examining these two safety behaviors, this was evidence that the adapted constructs behaved in a consistent manner across behaviors that are designed to protect OR nurses.

This study agrees with the findings of other studies that have shown the positive influence that low levels of perceived barriers, greater perception of enabling factors (i.e., high perception of one's skills in performing safety procedures), and environmental factors such as existing institutional programs, including policies, and employee training has on safety behaviors. (Stringer et al., 2009; Stringer et al., 2011; Gershon et al., 1995; Zohar, 2002; Zohar, 2003; Osborne, 2003(a); Osborne, 2003[b]). These three factors were consistent in both the SESIP and HFT model. In developing the PRECEDE model, the "environmental" factor addressed the nurses' experiences with knowledge of the existence of a policy on SESIP or HFT use. In the case of SESIPs, these factors were highly influential, with those who reported higher scores being approximately five-fold more likely to use SESIPs. Similarly, those reporting higher levels of perception of enabling factors and higher scores on reported training experiences were five times and almost three times more likely to be SESIP users, respectively. These findings are important because they support recommendations to increase intervention efforts aimed at improving in those areas. Our findings for the use of HFT also demonstrate that knowledge of mandatory policies is a significant predictor of the nurses' practice of the safety behaviors of interest—positive responses to the environmental factor item were also associated with a five-fold increase in the use of HFT.

An important concurrent finding regarding environmental policies was that only 22% of the nurses affirmed having knowledge of an institutional policy for the use of HFT, and less than half of them admitted knowing of such a policy for SESIP needle use.

Interventions aimed at both increasing the existence of mandatory use policies for institutions that do not currently have them and education of workers so they are aware of established policies are key steps to increasing compliance.

Enabling factors such as "high" levels of confidence in one's skill in using SESIP needles and having adequate supplies of SESIPs resulted in a five-fold effect on the nurses' use. We observed a two-fold effect from this factor on use of HFT. Other studies have also shown measures of self-efficacy as positively influencing safety behaviors [Efsthahiou, 2011; Osborne, 2003(b)]. The strength in these associations underscores the need for institutions to ensure that workers are skilled in performance of these safety practices. One way to improve on skill is through increased training using methods that are efficacious.

Our examination of the influence of training showed a very strong influence of training on use of SESIP needles. In particular, positive responses indicating workers were specifically trained on how to use SESIP needles resulted in almost three times the likelihood that one would use them. Many studies have highlighted the importance of training (Ganczak 2007; Stringer et al., 2009(a); Stringer et al., 2009[b]; Stringer et al., 2011; Osborne, 2003[a]; Berguer, 2004; Gershon et al., 1995). Although training on the use of HFT was not significantly associated with the use of that technique, the results demonstrated stronger associations between training and use of SESIPs than with use of HFT, the influence of training was also in the positive direction with HFT.

A comparison of the final models must take into consideration that these are not identical populations. Those evaluated for the use/non-use of SESIPs work in institutions that have already adopted and invested in the safety engineered devices. It is logical that they will train specifically on the use of newly introduced techniques. In fact more than 80% of those nurses reported that they had been trained in the use of SESIPs, compared to reports that only 65% have been trained on the use of HFT. These results point to the potential for improved SESIP use with training of those not yet trained. In contrast, the HFT procedure may be seen as a more commonly understood behavior, and less important as a training priority.

It is also worth considering ways in which the OR population becomes aware and facile with safety techniques even before being hired. For example, training on bloodborne pathogens is now a common part of nursing education, but awareness of the institution's role in the need for policies and the means by which new devices are selected and introduced should be a part of that training.

In the HFT model, the HBM constructs had stronger associations with use than that reflected in the SESIP model. Based on the construct measuring barriers to use, nurses who reported that they did not feel that either safety method caused interference with procedures or was too time consuming were at least twice as likely to use that respective technique. Our findings are consistent with other studies that have looked at HBM constructs as influences of safety behaviors (Osborne, 2003[b]; Efstathiou et al., 2011; Powers et al., 2016). "High" perceptions of benefits of use were significant only in relation to HFT use. The nurses' belief that HFT use reduced their risk of injury was significantly associated with greater use of HFT and, this finding is consistent with a previous study using HBM to examine OR-related safety behaviors. [Osborne, 2003(b)] This may be related to the fact that HFT may be seen as a tried and true safety behavior. These findings may inform interventions directed at improving SESIP use by further exploring perceived barriers and clarifying the potential benefits of improved compliance.

4.5.1 Strengths and Limitations

Not unexpectedly, we encountered the issue of a low response rate that is typically seen with nationally distributed electronic surveys. However, we were able to compare characteristics of the sample population to their organization, AORN, and were able to show that respondents were comparable to the overall membership on distribution of age, gender, and job titles. We also were able to show a varied distribution of institutions according to size, public versus private affiliation, medical specialties, job titles, and geographic region. There is also the possibility that institutions may be represented by more than one nurse; thereby providing greater weight to responses that characterize a specific institution. This was unavoidable if respondents were to be assured anonymity, but, again, the variability in institution characteristics suggests a broad representation of places of employment.

We are reminded to be cautious in generalizing findings, because nurses represent only one profession on surgical teams. However, many of the factors examined in this study apply to others in surgical settings in which others may benefit from interventions at the institutional level, such as developing and maintaining policies, providing training, and involving the employees in the selection and introduction of improved safety measures.

The design of this study, and cooperation of the only professional organization of practicing OR nurses, allowed us to reach a nationwide population that is at risk of serious consequences should safety measures fail or be disregarded. The use of the modified PRECEDE model as a framework to simultaneously analyze these constructs at the individual and organizational level is a novel approach that adds to the body of literature.

4.6 CONCLUSION

This is the first study to use this modified PRECEDE model as a framework of examining two important techniques that exist to protect operating room nurses. It addresses a healthcare population that to date has not seen a fall in rates of percutaneous injury when compared to the experience of their peers in other specialties. It confirms the increased likelihood that positive safety behaviors will be followed when institutions foster safe work practices in general.

An important finding is the similarity in the final models for each safety behavior. This study is consistent with the findings of others that show the overall influence of perceived barriers, enabling factors (e.g., high perception of one's skills in performing safety procedures), existing institutional programs and training on compliance with safety practices (Stringer et al., 2009; Stringer et al., 2011; Osborne, 2003[b]; Gershon, 1995). However, the tailored versions of the scales that more specifically characterize these constructs as they apply to OR nurses provide insight into specific factors that influence the use of these two techniques in operating rooms. For these outcomes, the organizational environment was measured by the reported existence and awareness of an institutional policy regarding safety measures in the OR. This was one of the strongest predictors of safety behavior. It may even be a marker of the institution's overall regard for worker safety. The establishment of a policy should be considered foremost in importance for improving safety practices. Additionally, the relatively low proportion of institutions with reported policies in place or that provide safety engineered needles is a concern.

Overall, it appears that the likelihood that nurses will use safety engineered needles or engage in hands free passing practices lies largely with the facilities in which they work—making devices available, implementing policies for their mandated use, and training on the use of safety techniques. The next step should be to identify interventions that are aimed at designing methods of worker education that take into account individual level perceptions and behaviors, such as perceived barriers and enabling factors, and at increasing the existence and awareness of effective mandatory use policies at the institutional level.

Table 4.1. Survey Items evidencing internal consistency for the HBM scales ***(Predisposing Factors)***

Survey Item	Correlation with scale	Cronbach's α (Osborne)[20]	Cronbach's α (Champion)[6]
Susceptibility Items			
- My chance of getting HepB, C/HIV is high	.82		
- I have contact with many patients infected with Hep B, C/HIV	.86		
- There's little chance I'll get HepB, C/HIV from work	.79		
Cronbach's Alpha (α)	.77	.71	.78
Severity Items			
- If I get Hep B/Hep C or HIV, my career would be endangered	.86		
- If I get Hep B/Hep C or HIV, my financial security would be endangered	.85		
- If I get Hep B/Hep C or HIV, a significant relationship in my life would be endangered	.78		
Cronbach's Alpha (α)	.76	.70	.78
Benefit Item(s)			
Use of SESIP needle			
- Using safety-engineered hypodermic needle decreases my risk of acquiring Hep B/Hep C/HIV	-		
--			
Use of Hands-free technique (HFT)			
- Using the HFT decreases my risk of acquiring Hep B/Hep C/HIV	-		
Cronbach's Alpha (α) - *N/A; Single item used for Benefit*	-	.51	.61
Barrier scale			
Use of SESIP needle			
- SESIP hypodermic needles interfere with many procedures performed in my OR	.80		
- SESIP syringes too time consuming to always use	.77		
- SESIP needles interfere w/administering incremental doses of anesthetics	.78		
Cronbach's Alpha (α)	.68	.76	.76
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Use of Hands-free technique (HFT)			
- HFT interfere with many procedures performed in my OR	.86		
- HFT is too time consuming to always use	.86		
Cronbach's Alpha (α)	.64	.76	.76

Note: The survey instrument was originally developed by Champion (1984) and later modified and used by Osborne (2003). It was further adapted for this study. This table compares Cronbach's alpha results from all three studies using this survey instrument.

Table 4.2 Construct items used as measures of enabling, reinforcing and environmental factors

Survey Items
Enabling Factor Items
Use of SESIP needle
- I am skilled in use of SESIP needle
- SESIP needles are supplied in my OR
- SESIP needles are too expensive to use $^{\Omega}$
- Supplies of SESIP needles are limited at my facility $^{\Omega}$

Use of Hands-free technique (HFT)
- I am skilled in use of HFT
- Supplies for HFT are limited at my facility $^{\Omega}$
Reinforcing Factor Items
Use of SESIP needle
- I am more likely to use SESIP needles if my peers use them
- I am more likely to use SESIP needles if a senior team member uses them
- I am more likely to use SESIP needles if the patient is infected w/ HIV/Hep B/Hep C

Use of Hands-free technique (HFT)
- I am more likely to use HFT if a senior team member uses them
- I am more likely to use HFT if the patient is infected w/ HIV/Hep B/Hep C
- I am less likely to use HFT in an emergency $^{\Omega}$
Environmental Factor Items
Use of SESIP needle
- Employer has mandatory policy to use SESIP needles

Use of Hands-free technique (HFT)
- Employer has mandatory policy to use HFT

Note: Single item measuring awareness of a policy was used for Environmental factor

$^{\Omega}$ These items were reverse-coded so Strongly agreed received the lowest score / Strongly disagreed received the highest score

Table 4.3 Distribution of PRECEDE constructs by use of SESIP needles (n=306) [λ] and HFT (n=427)

Factor	# of items	Maximum possible score	Range min - max	Median score (IQR)
Predisposing *(HBM Constructs)*				
Susceptibility	3	12	0 - 12	7 (5 - 9)
Severity	3	12	0 - 12	9 (7 - 12)
Barriers *(SESIP needle)*	3	12	2 - 12	8 (6 - 9)
Benefit [+] *(SESIP needle)*	1	4	0 – 4	4 (3 - 4)
Enabling (*SESIP needle)*	4	16	2 – 16	12 (9 - 14)
Reinforcing (*SESIP needle)*	3	12	0 – 12	7 (3 - 9)
Environment [+] (*SESIP needle)*	1	1	--------	---------
Predisposing *(HBM Constructs)*				
Susceptibility	3	12	0 - 12	7 (5 - 9)
Severity	3	12	0 - 12	9 (7 - 12)
Barriers *(HFT)*	2	8	0 - 8	8 (4 - 6)
Benefit [+] *(HFT)*	1	4	0 – 4	3 (3 - 4)
Enabling (*HFT)*	2	8	0 – 8	5 (4 - 6)
Reinforcing (*HFT*	3	12	1 – 12	6 (5 - 8)
Environment [+] (*HFT)*	1	1	--------	---------

[λ] n=306; 14 participants did not qualify to use safe needles b/c hypodermic needles were not used by surgeons in their ORs and 107 participants did not qualify b/c SESIPs were not available in their OR unit. [+] Perception of benefit and the environmental factor were measured with 1 item each.

Table 4.4 Distribution of selected demographic and work-related variables by HFT use (n=427) and SESIP needle use (n= 306 [λ])

Demographic Variable	**Overall** n=427 n (col %)	**HFT user[γ]** n= 180 n (row %)	**X^2** *(df)* p-value	**Overall** n=306 n (col %)	**SESIP needle user[γ]** n= 140 n (row %)	**X^2** *(df)* p-value
Age						
≤ 30 years old	21 (4.92)	7 (33.33)		15 (4.90)	3 (20.00)	
31- 40 years old	64 (14.99)	31 (48.44)	2.55 *(5)*	47 (15.36)	19 (40.43)	5.82 *(5)*
41- 45 years old	50 (11.71)	21 (42.00)	p=0.768	32 (10.46)	16 (50.00)	p=0.324
46 - 50 years old	61 (14.29)	27 (44.26)		50 (16.34)	22 (44.00)	
51 - 55 years old	99 (23.19)	43 (43.43)		67 (21.90)	32 (47.76)	
≥56 years or older	132 (30.91)	51 (38.64)		95 (31.05)	48 (50.53)	
Gender						
Male	37 (8.67)	10 (27.03)	3.80 *(1)*	27 (8.82)	14 (51.85)	0.44 *(1)*
Female	390 (91.33)	170 (43.59)	p=0.051	279 (91.18)	126 (45.16)	p=0.505
Job title (dichotomized)						
Managers	69 (16.16)	44 (63.77)	**15.77** *(1)*	50 (16.34)	29 (58.00)	3.61 *(1)*
Non-managers	358 (83.84)	136 (37.99)	**p<0.001**	256 (83.66)	111 (43.36)	p=0.057
Time in current job (*in #months)*						
1-12 months	36 (8.43)	15 (41.67)		23 (7.52)	11 (47.83)	
13-60 months	157 (36.77)	73 (46.50)	**9.59** *(4)*	114 (37.25)	53 (46.49)	4.59 *(4)*
61-120 months	78 (18.27)	38 (48.72)	**p<0.05**	61 (19.93)	34 (55.74)	p=0.332
121-240 months	79 (18.50)	33 (41.77)		53 (17.32)	21 (39.62)	
>240 months	77 (18.03)	21 (27.27)		55 (17.97)	21 (38.18)	
OR unit worked						
General Surgery	143 (33.49)	64 (35.56)		102 (33.33)	40 (28.57)	**12.64** *(4)*
Orthopedic Surgery	116 (27.17)	59 (32.78)	**10.26** *(4)*	81 (26.47)	48 (34.29)	**p<0.05**
Cardiothoracic & Obstetrics	26 (6.09)	10 (5.56)	**p<0.05**	15 (4.90)	10 (7.14)	
Neuro/Opthal/Otolaryngology	42 (9.84)	17 (9.44)		33 (10.78)	14 (10.00)	
Multidisciplinary	100 (23.42)	30 (16.67)		75 (24.51)	28 (20.00)	

[γ] HFT (or SESIP needle) users included those who *Usually* or *Always* used; non-users were those who used HFT (or SESIP needle) *Half-time/Seldom/Never*
[λ] SESIP needle n=306; participants did not qualify to use safe needles if hypodermic needles were not used by surgeons in their ORs nor if SESIPs were unavailable
Chi square test. **Bold** text is statistically significant.

Table 4.5 Distribution of safety practices and facility policies by HFT use (n=427) and by SESIP needle use (n= 306 [*])

Safety Practice/Policy	**Overall** n=427 n (col %)	**HFT user**$^{\gamma}$ n=180 n (row %)	**X^2** *(df)* p-value	**Overall** n= 306 n (col %)	**SESIP needle user**$^{\gamma}$ n=140 n (row %)	**X^2** *(df)* p-value
Use hands-free technique, when passing sharps		-----------	------------	------------	------------	------------
No (*Irregular use*)	247 (57.85)					
Yes (*Regular use*)	180 (42.15)					
Use of SESIP needles						
No (*Irregular use*)	------------	------------	------------	166 (54.25)	-----------	------------
Yes (*Regular use*)				140 (45.75)		
Facility has mandatory policy on use of SESIPs needles*	------------	------------	------------			**73.95** *(1)*
No				173 (56.54)	42 (24.28)	**p<0.001**
Yes				133 (43.46)	122 (73.68)	
Facility has mandatory policy on use of HFT			**58.98** *(1)*	------------	------------	------------
No	335 (78.45)	109 (32.54)	**p<0.001**			
Yes	92 (21.55)	71 (77.17)				
Announce transfers, when passing sharps						
No (Uns*afe*)	125 (29.27)	28 (22.40)	**28.28** *(1)*	89 (29.08)	30 (33.71)	**7.33** *(1)*
Yes (*Safe*)	302 (70.73)	152 (50.33)	**p<0.001**	217 (70.92)	110 (50.69)	**p<0.01**
Recapping used needles**						
Yes (*Unsafe)*	186 (45.04)	63 (45.04)	**7.42** *(1)*	136 (44.44)	41 (30.15)	**24.02** *(1)*
No (*Safe*)	227 (54.96)	107 (54.96)	**p<0.01**	170 (55.56)	99 (58.24)	**p<0.001**
Input in selection of SESIPs						
No	-----------	------------	------------	105 (34.31)	36 (34.29)	**8.47** *(1)*
Yes				201 (65.69)	104 (51.74)	**p<0.01**

HFT (or SESIP needle) users included those who *Usually* or *Always* used; non-users were those who used HFT (or SESIP needle) *Half-time/Seldom/Never*
*n=306; participants did not qualify to use safe needles if hypodermic needles were not used by surgeons in their ORs nor if SESIPs were unavailable
Does not add up to total due to missing responses [∂]Chi square test. **Bold text is statistically significant.

Table 4.6 Associations between training experiences and SESIP needle use (n=306)

Survey Item	Overall n (%)	SESIP user n (%)	X^2 *(df)*	p-value
Training Items related to SESIP needle use				
Employer provided training on how to use the safety-engineered hypodermic needles[#]				
No	46 (15.92)	8 (5.71)	**21.12** *(1)*	**p<0.001**
Yes	243 (84.08)	132 (94.29)		
Employer provides training each time a new SESIP needle is selected [*]				**p<0.001**
No	47 (15.36)	10 (7.14)	**13.40** *(1)*	
Yes	259 (84.64)	130 (92.86)		
General Training Items				
Employer has provided training on OSHA requirements relating to sharps safety, in past 12 months	96 (31.37)	35 (25.00)	**4.87** *(1)*	**0.027**[§]
No	210 (68.63)	105 (75.00)		
Yes				
Employer has provided training on the risks associated with OR sharps injuries, in past 12 months	83 (27.12)	29 (20.71)	**5.36** *(1)*	**0.021**[§]
No	223 (72.88)	111 (79.29)		
Yes				
Employer has provided training on facility's sharps safety policies, in past 12 months	89 (29.08)	51 (24.52)	**4.85** *(1)*	**0.028**[§]
No	217 (70.92)	157 (75.48)		
Yes				

[#]Sample size differs due to missing responses. Only column frequencies shown
SESIP needle users include those who use *Usually* and *Always*; those who use *Half-time*/*Seldom/Never* are HFT non-users
Chi Squared test; **Bold** text is statistically significant [§]Significant results: p<0.05

Table 4.7 Associations between training experiences and HFT use (n=427)

Survey Item	Overall n (%)	HFT user n (%)	X^2 *(df)*	p-value
Training Items related to HFT use				
Employer has provided training on use of HFT, in past 12 months			**21.26** *(1)*	**p<0.001**
No	148 (34.66)	40 (22.22)		
Yes	279 (84.08)	140 (77.78)		
General Training Items				
Employer trained on OSHA requirements relating to sharps safety, in past 12 months				
No	143 (33.49)	43 (23.89)	**12.88** *(1)*	**p<0.001**
Yes	284 (66.51)	137 (76.11)		
Employer trained on the risks associated with OR sharps injuries, in past 12 months				
No	124 (29.04)	34 (18.89)	**15.56** *(1)*	**p<0.001**
Yes	303 (70.96)	146 (81.11)		
Employer has provided training on facility's sharps safety policies, in past 12 months				
No	135 (31.62)	37 (20.56)	**17.61** *(1)*	**p<0.001**
Yes	292 (68.38)	143 (79.44)		

[γ] HFT users include those who use *Usually* and *Always*; those who use *Half-time*/*Seldom/Never* are HFT non-users.
Only column frequencies shown Chi Squared test; **Bold** text is statistically significant

Table 4.8 Bivariate logistic regression models of associations between PRECEDE constructs and use of SESIP needles (n=306) or HFT (n=427)

Factor	Bivariate Model (SESIP needle use)		Bivariate Model (HFT use)	
	OR	95% CI	OR	95% CI
Predisposing *(HBM Constructs)*				
Susceptibility	1.04	(0.66 - 1.64)	1.06	(0.72 - 1.56)
Severity	1.13	(0.70 - 1.81)	1.05	(0.70 - 1.58)
Barriers	**2.42**	**(1.53 - 3.85)**§§	**3.55**	**(2.33 - 5.41)**§§
Benefit+	1.43	(0.91 - 2.25)	**3.82**	**(1.98 - 7.40)**§§
Enabling	**8.21**	**(5.26 - 12.8)**§	**3.17**	**(2.08 - 4.83)**§§
Reinforcing	0.77	(0.52 - 1.13)	1.48	(0.97 - 2.25)
Environment+	**8.73**	**(5.20 - 14.68)**§§	**7.01**	**(4.09 - 12.00)**§§

Bivariate, unadjusted logistic regression models for each outcome + Single item used to measure benefit and environmental factors
Bold text is statistically significant §Significant results: $p<0.05$); §§Significant results, $p<0.001$

Table 4.9 Adjusted logistic regression models of associations between PRECEDE constructs and SESIP needle use (n=306)

Factor	Multivariate Model 1			Multivariate Model 2		
	OR	95% CI	p-value	OR	95% CI	p-value
Predisposing *(HBM Constructs)*						
Susceptibility	0.95	(0.51 - 1.74)	p=0.86	0.94	(0.50 - 1.75)	p=0.83
Severity	1.30	(0.69 – 2.45)	p=0.43	1.44	(0.74 – 2.80)	p=0.28
Barriers *(SESIP needle)*	1.59	(0.88 – 2.86)	p=0.13	**1.99**	**(1.03 – 3.73)**	**p<0.05**
Benefit+ *(SESIP needle)*	0.81	(0.44 – 1.47)	p=0.48	0.66	(0.35 – 1.25)	p=0.21
Enabling *(SESIP needle)*	**5.86**	**(3.02 – 11.39)**	**p<0.001**	**5.15**	**(2.59 – 10.20)**	**p<0.001**
Reinforcing *(SESIP needle)*	1.04	(0.89 – 1.85)	p=0.89	1.25	(0.68 – 2.29)	p=0.47
Environment+ *(SESIP needle)*	**6.42**	**(3.59 – 11.46)**	**p<0.001**	**4.78**	**(2.59 – 8.83)**	**p<0.001**
Job Title						
Non-managers		-------			reference	
Managers				0.96	(0.44 – 2.11)	p=0.92
Trained on how to use SESIP needles						
No		-------			reference	
Yes				**2.76**	**(1.05 – 7.26)**	**p=0.04**
Trained on each newly selected SESIP device						
No		-------			reference	
Yes				2.43	(0.97 – 6.11)	p=0.059

Model 1 - the four Precede factors, i.e., the predisposing (4 HBM) constructs, enabling, reinforcing and environmental factors in a multivariate logistic regression (MLR) model. +Single item used to measure benefit and environmental factors. Model 2 – MLR that includes the predisposing (4 HBM) constructs, enabling, reinforcing and environmental factors adjusted for job title and SESIP-related training. **Bold** text is statistically significant

Table 4.10 Adjusted logistic regression models of associations between PRECEDE constructs and HFT use (n=427)

Factor	Multivariate Model 1			Adjusted Multivariate Model		
	OR	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Predisposing *(HBM Constructs)*						
Susceptibility	0.87	(0.54 - 1.39)	p=0.56	0.92	(0.57 - 1.49)	p=0.73
Severity	1.10	(0.67 – 1.80)	p=0.70	1.07	(0.65 – 1.76)	p=0.78
Barriers *(HFT)*	**2.67**	**(1.65 – 4.31)**	**p<0.001**	**2.62**	**(1.61 – 4.25)**	**p<0.001**
Benefit+ *(HFT)*	**2.73**	**(1.31 – 5.71)**	**p<0.01**	**2.60**	**(1.24 – 5.46)**	**p<0.05**
Enabling *(HFT)*	**1.85**	**(1.15 – 2.97)**	**p<0.05**	**1.77**	**(1.09 – 2.86)**	**p<0.05**
Reinforcing *(HFT)*	1.48	(0.91 – 2.41)	p=0.11	1.52	(0.93 – 2.48)	p=0.09
Environment+ *(HFT)*	**5.49**	**(3.10 – 9.70)**	**p<0.001**	**4.52**	**(2.46 – 8.31)**	**p<0.001**
Job Title		-------				
Non-managers					reference	
Managers				**2.11**	**(1.15 – 3.88)**	**p<0.05**

Trained on how to use HFT						
No					reference	
Yes				1.37	(0.82 – 2.26)	p=0.22

Model 1 - the four Precede factors, i.e., the predisposing (4 HBM) constructs, enabling, reinforcing and environmental factors in a multivariate logistic regression (MLR) model. + Single item used to measure benefit and environmental factors. Model 2 – MLR that includes the predisposing (4 HBM) constructs, enabling, reinforcing and environmental factors adjusted for job title and training on the use of HFT. **Bold** text is statistically significant

CHAPTER 5. DISCUSSION AND POLICY CONSIDERATIONS

5.1 OVERVIEW

The Centers for Disease Control and Prevention (CDC) has estimated that hospital workers are exposed to more than 384,000 percutaneous injuries (PIs) each year. (Panlilio, 2004) These estimates may under-represent the burden of PIs to healthcare workers, since it is believed that as much as 56.6% of all needlestick injuries go unreported. (Panlilio et al., 1998; Doebbeling et al., 2003; Vose 2009) Sharps injuries place healthcare workers at risk of acquiring potentially deadly or life-altering diseases such as hepatitis B, hepatitis C, and human immunodeficiency virus (HIV). Despite the existence of longstanding Occupational Safety and Health Administration (OSHA) regulations requiring employers to implement use of *feasible* engineering and work practice controls as primary means of eliminating or minimizing workers' exposure to contaminated sharps, healthcare workers continue to sustain needlestick/sharps injuries. The path to achieving optimal sharps safety practices in healthcare has many challenges but it is particularly challenging when considering improvements in operating rooms (ORs).

Gielen and Green analyzed the impact that multilevel, multicomponent intervention methods—tenets of the PRECEDE-PROCEED model—have had in influencing success in reducing motor vehicle- and tobacco-related deaths and other adverse outcomes. (Gielen & Green, 2015) They discussed the potential utility of the

PRECEDE-PROCEED framework in helping to plan interventions to address other issues in public health. In doing this, they identified several aspects of the inter-woven ecological model that worked in favor of motor vehicle- and tobacco-related safety improvements: a) *reciprocal determinism, b) surveillance, research, and evidence-based practice, c) comprehensive and culturally appropriate interventions, and d) public support and advocacy,* all of which are easily applicable to the historical and current efforts to address sharps-related safety in healthcare. Below is a discussion of the ways in which our findings relate to this model with regard to sharps-related safety and plans for potential interventions, with particular emphasis on the importance of research.

5.2 BACKGROUND

5.2.1 Reciprocal determinism - application to sharps-safety

Gielen and Green discussed the applicability of this aspect of the PRECEDE model to motor vehicle safety by relating historical events that demonstrate how individuals have affected the environment (e.g., through individual or collaborative advocacy for safer practices relating to drunk driving or infant car seat use) and the influences that the environment, in turn, has had on individuals (e.g. through organizational or political institutions/laws/policies). (Gielen and Green, 2015)

Similar relationships between individuals and environment have existed (and continue to exist) with the efforts to address sharps safety. In the 1980s, changes in the healthcare environment generated from the spread of HIV spurred activism on the parts of organized labor unions, medical device manufacturers, nurses, and other worker advocates. (OSHA Bloodborne Pathogens Standard (preamble), 1991; Jagger et al., 2008;

Berguer, 2004; Berguer, 2005) Those individual and collaborative actions motivated development of organizational and state-level policies, all of which ultimately led to federal-level regulations/policies (i.e., 29 CFR 1910.1030, the Bloodborne Pathogens (BBP) Standard mandating certain protective measures to prevent bloodborne pathogens exposures and sharps injuries in healthcare. (OSHA standard (preamble), 1991) In 2000, actions of many of the same stakeholders further influenced Congress to pass the Needlestick Safety and Prevention Act, which mandated additional requirements from OSHA to protect healthcare workers, including an added definition of sharps with engineered sharps-injury protections (SESIPs) and a requirement for annual review and implementation of newer and safer devices as primary control measures. [OSHA standard, 2001(a)]

OSHA updated the BBP standard in 2001, and the revised OSHA standard was influential in the subsequent improvements of SESIP designs from manufacturers. (Jagger et al., 2008) As the OSHA regulation requires employers to evaluate safer needles/sharps each year and to select devices that are *feasible* for medical procedures, new and improved technology enhanced *feasibility* at the institutional level and enabled stronger OSHA enforcement. Some benefits from those stakeholder actions are evidenced by the citation history of the BBP standard. As Figure 6.1 shows, shortly after the standard was updated, there was a sharp increase in the number of citations issued for section 29 CFR 1910.1030(d)(2)(i), the paragraph requiring use of safety-engineered devices. By 2003, OSHA citations for 1910.1030(d)(2)(i) were at an all-time high. (OSHA IMIS and OIS data) Though the high number of violations was not sustained, over the decade following the 2001 standard revision, 1910.1030(d)(2)(i) remained among the top five most frequently cited sections of the BBPS. Prior to 2001, that section averaged well below the top 10 most frequently cited sections (OSHA IMIS and OIS data).

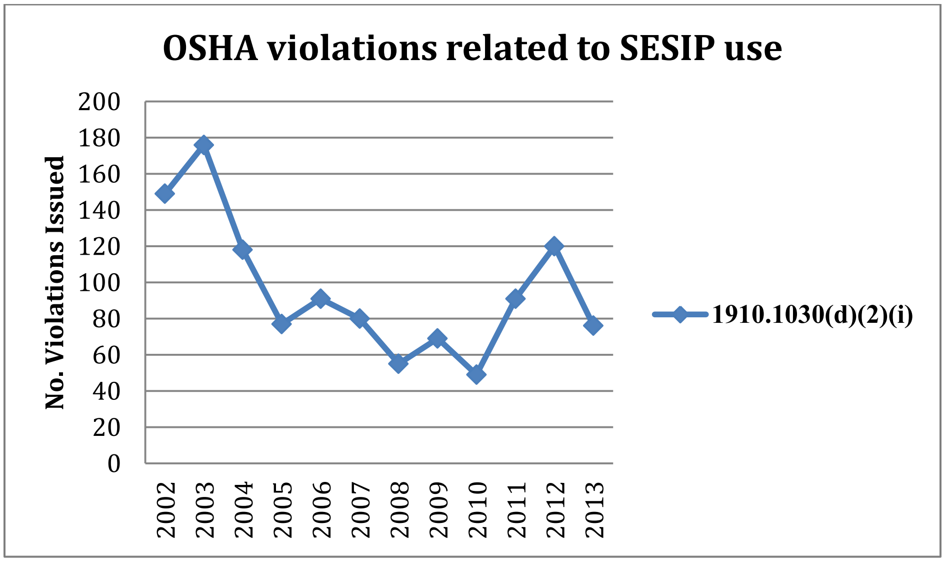


Figure 6.1 – OSHA Citations 2002-2013. Data from the OSHA Integrated Management Information System (IMIS), 2002-2011, and OSHA Information System (OIS), 2012-2013.

5.3 CHARACTERIZATION OF SAFETY BEHAVIORS AMONG OR NURSES IN THE UNITED STATES

5.3.1 Surveillance, research, and evidence-based practice

The example of progress made in motor vehicle safety has been used to emphasize benefits achieved through surveillance of crashes and circumstances surrounding them as well as periodic monitoring of motorists’ behaviors and of measures implemented to modify such behaviors. (Gielen and Green, 2015)

The positive influence of research and evidence-based practice can also be illustrated by previous and ongoing research to address sharps-related injuries. [Gershon et al., 1999; Alvarado-Ramy et al., 2003; Whitby, 2008; Adams, 2006; Hoffman, 2013; Stringer et al. 2009(b)] Major credit is owed to surveillance data from the Exposure Prevention Information Network (EPINet), a data collection system developed in 1992 at the University of Virginia's International Healthcare Worker Safety Center, and the Massachusetts Sharps Injury Surveillance System (MSISS). The EPINet collects voluntarily submitted data from hospitals across the country, and MSISS is a statewide surveillance system that requires annual submission of needlestick injury data from all hospitals licensed by the Massachusetts Department of Public Health (MDPH). Data from these surveillance systems have been cornerstones of decades of research endeavors that have brought attention and progress to sharps-safety issues.

Research using EPINet data has shown sharps-related injury rates continue to increase in surgical settings relative to non-surgical departments; for instance, from 1993 through 2006, percutaneous injuries (PIs) declined by 31.6% in non-surgical settings but increased by 6.5% in ORs. (Jagger et al., 2010) Continued surveillance of outcomes and behaviors and continued research that highlights the practices and evidence of successful measures employed in surgical settings can help to achieve improvements more broadly.

It is through surveillance that we have been made aware that the three sharp instruments involved in the majority of percutaneous injuries (PIs) in the OR are suture needles (43.4%), scalpels (17%), and syringes (12%). (Jagger et al., 2010; MDPH, 2008) Through research, we are aware of successful implementation of SESIP needles in non-surgical environments. (Orenstein, 1995; Clarke, 2002; Slater and Whitby, 2007; Whitby, 2008; Jagger et al., 2008; Jagger et al., 2010; Valls, 2007; Hoffman, 2013; Alvarado-Ramy, 2003; Laramie, 2011) Our research was largely influenced by findings from Jagger et al.'s 2010 study that highlighted a need for more efforts to impact operating room sharps-safety practices.

We conducted two studies using data from a web-based survey of practicing OR nurses who were members of the Association of peri-Operative Registered Nurses, (AORN). We looked at the availability and implementation of two longstanding safety behaviors used to prevent PI in surgical settings—safety-engineered sharps injury protection (SESIP) needles and hands-free passing techniques (HFT). Our first study examined and characterized these reported safety practices among operating room nurses. Among the findings, our study highlighted a major concern in that only 72% of respondents worked in environments in which SESIPs were available in their ORs. Of that population, only 46% of participants reported their own use of SESIP needles. Use of HFT in the same population was 43%. The low rates of compliance found in this study are consistent with findings of previous healthcare-related research. (Clarke, 2002; Stringer, 2009(a); Stringer, 2009(b); Jeong, 2009). When we examined other safety practices, we found compliance with the practice of announcing sharps transfers to be less than 100%—approximately 71% affirmed regularly announcing transfers. Additionally, about 45% of the nurses in our study admitted to regularly recapping used needles—this is an unsafe practice that is prohibited by OSHA. We also found that only 17% of responders reported awareness of the existence of mandatory policies for both the use of HFT as well as use of SESIP needles in their facility, and approximately 49% had neither. Some responders did not know whether their facilities had mandatory policies for the use of either SESIP needles (approximately 19%) or HFT (approximately 15%). Among the implications for employers, these findings suggest a significant rate of non-compliance with several provisions in the existing regulations, and it suggests that many employers lack concern for their workers' safety.

Further, our study adds to the existing literature by examining compliance with additional requirements set by OSHA in its 2001 update to the Bloodborne Pathogens Standard. For example, we looked at the varying levels of solicitation of input from non-managerial workers in ORs across the United States. Approximately 66% affirmed that they had provided input in SESIP selection; and, 75% affirmed that their peers provided such input. The rate of SESIP needle use was also higher among those who reported input in selection by their peers and it was significantly higher among those who reported input by themselves. While it is not mandatory that every worker is included in the device selection process—a representative sample is adequate—this finding does suggest positive implications of open communication. Institutions could potentially improve compliance among workers by simply taking steps to assure that all affected workers—not just those involved in the selection of devices—are made aware of the selection process and of peer-involvement in the process. Future research focusing on the impact from various safety device selection schemes (i.e., ones ranging from simple surveys of affected employees to full, hands-on trials of devices) could provide more concrete guidance as to the most effective mechanism(s) for improving compliance among surgical staff.

In our second study, we used a modified PRECEDE framework—i.e., simultaneous examination of predisposing factors, operationalized with items measuring

HBM constructs, enabling, reinforcing, and environmental factors—to assess several key factors that influence SESIP needle use and factors associated with use of hands-free passing technique (HFT) among OR nurses. Our aim was to identify similarities and/or differences in individual-level as well as environmental factors that influence the use of each of these safety-related practices. Several previous studies have used research tools, including the Health Belief Model (HBM), to assess perceptions and safety behaviors among healthcare workers (Osborne, 2003(a); Osborne, 2003(b); Powers, 2016; Efstathiou, 2011). Various other approaches have been used to look at a combination of individual-level and organizational influences on healthcare workers' use of universal precautions and personal protective equipment. (Gershon et al., 1995; Gershon et al., 1999; Gershon et al., 2000; Clarke et al., 2002; Clarke, 2007) Our research is the first that we are aware of that has utilized this modified PRECEDE framework that incorporates the HBM to examine influences on use of SESIPs and HFT in ORs across the country.

In general, we found a greater proportion of users of SESIP needles (and of HFT) reported positive scores on the modified PRECEDE constructs. Our study is consistent with findings of other studies that show the positive influence that low levels of perceived barriers, greater enabling factors (i.e., high perception of one's skills in performing safety procedures), and positive environmental factors such as existing institutional programs has on use of SESIP needles and HFT. [Stringer et al., 2009(b); Stringer et al., 2011; Gershon et al., 1995; Zohar, 2002; Zohar, 2003; Osborne, 2003(a); Osborne, 2003(b); Berguer, 2004] Additionally, our model that tested influences on SESIP needle use found training to be a significant predictor of use; and, our HFT model found "high" perceptions of benefits to be a significant predictor of the nurses' use of HFT.

Specifically, our findings clearly showed that knowledge of an existing mandatory policy was an extremely influential factor in the reported use of both SESIP needles and HFT. The nurses who reported knowledge of existing mandatory policies in their workplaces for either SESIP needle use or HFT use were five times more likely to use them. It is therefore as important for workers to be aware of the policies that exist in their workplaces, as it is that institutions establish policies in the first place. It is also possible that institutions that take the step of developing policies are also the ones that foster a culture of safety among employees, a movement that is increasingly being recognized as a strong facilitator of overall worker safety. (Zohar, 2003; Zohar, 2003; Gershon et al., 1995; Gershon et al., 2000; Clarke, 2002)

Greater use of HFT was strongly associated with "high" enabling scores (i.e., strong views on ones skills and availability of safety supplies). In the SESIP model, the level of influence of enabling factors resulted in five times greater use of SESIP needles and the measure of specific SESIP needle training had a three-fold effect on the use of SESIP needles.

Although the unit of analysis for our study is the worker, not the institution, results provide a picture of the conditions and safety behavior of the overall OR nurse population. These findings offer compelling support for recommendations to increase intervention efforts aimed at improving in several areas.

5.4 INFLUENCE OF SAFETY PERCEPTIONS ON USE OF TWO SAFETY TECHNIQUES IN THE OR

5.4.1 Comprehensive and appropriate interventions

In their 2015 analysis, Gielen and Green described how motor vehicle interventions have been successful due to broadly applied approaches (i.e., at multiple levels—targeting individuals, communities, organizations, etc.; and through many sectors—education, law enforcement, etc.). (Gielen and Green, 2015) So too have there been attempts to target implementation of interventions at different levels to address OR safety.

Valuable knowledge gained from a number of previous sharps-related research findings have influenced efforts to improve OR safety through proposed intervention options such as *feasible* use of blunt sutures, sharpless surgical procedures (e.g., electrocautery methods to replace use of sharp scalpels in certain procedures), and hands-free passing techniques. (Jagger et al., 1998; Patterson, 1998; Berguer, 2004, 2005; Makary, 2006; Makary, 2007; Folin, 2000; Stringer et al., 2002; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b); Taylor, 2006; Vose, 2009; Herring, 2010; Jagger et al., 2010) Recommendations and policy statements from OSHA, the National Institutes for Occupational Safety and Health (NIOSH), and other influential organizations (e.g., AORN, and the American College of Surgeons, ACS) have been issued in support of the various safer work practices in the OR, owing largely to some of the aforementioned research findings. (Michaels, 2010; OSHA CPL, 2001(b), OSHA/NIOSH Bulletin, 2007; ACS, 2005; ACS 2007)

The importance of the appropriateness of interventions cannot be overstated. OSHA's regulation requires employers to evaluate safer needles/sharps each year and to select devices that are *feasible* for medical procedures; however, *feasibility* is often challenged with one of several affirmative defenses—the legitimacy of each has not been fully determined. Among them are the following claims: 1) SESIP needles are infeasible because SESIPs are not available for relevant gauges (sizes) of needles; 2) difficulty in discerning whether the use of a safer device would interfere with the practitioner's ability to correctly perform certain medical procedure(s), e.g., where use would create a greater hazard to employee(s) or patient(s), or whether refusal to use safer devices is a matter of personal preference. The first defense is not likely to be legitimately applied to many procedures in the OR, since hypodermic needles are most often used for injecting anesthetics and SESIP needles are commercially available for the most common gauges of needles used for local anesthetics, and SESIP needles are commonly used in non-surgical settings. The second defense, uncertainty about whether the failure to use a safer device is due to an actual *infeasibility* based on greater hazard to the practitioner(s) or patient, if legitimate, could present difficulty in enforcement at the institutional and at the regulatory levels.

In our second study, we examined the nurses' views of whether they felt SESIP needles interfered with surgical procedures and we found significant evidence to the contrary. Of importance was the finding that the majority of nurses did not regard SESIP needles as an interference with surgical procedures or as a time-consuming inconvenience. Similar views were reported regarding HFT use—nurses largely did not consider HFT use as interfering or too time consuming. While we recommend further research to better clarify the circumstances or specific surgical procedures for which claims of *infeasibility* for SESIP needle use are reliable, we believe several interim intervention options should be explored now. We must use the precautionary principle and act on what we do know.

In our study, out of the subset of responders who admitted to the use of needles in their ORs, approximately 45% reported regularly recapping used needles. Surveillance has shown this practice attributed to approximately 10% of needlsticks involving hypodermic needles between 1993 and 2006. (Jagger et al., 2010) Intervention is needed now in order to decrease the burden of injuries attributable to recapping of used needles. Based on anecdotal evidence, one reason that used needles are continuously recapped is to allow for the administration of incremental doses of local anesthetics. Our survey asked nurses whether they felt safety-engineered needles specifically interfered with incremental dosing of anesthetics and responses showed a large proportion did not feel SESIPs interfered with incremental dosing. An option that should be explored as an alternative to recapping is the use of prefilled, safety-engineered syringes with smaller doses of anesthetics. Prefilled, safety needles became more widely available after the revision of OSHA's standard. Their use is far more common in non-surgical settings than in the OR. It is a viable option for reducing the risk of PIs from needle recapping.

Overall, our findings showed the use of SESIP needles and HFT are both strongly associated with other positive behaviors. Improvements in the culture of safety within facilities can improve safety compliance rates. At the institutional level, strong effective comprehensive safety programs that involve workers of all levels (managers and non-managers) must be fostered. To be effective, such programs must be supported by the organization through evident investment in both human and financial commitment. Ongoing evaluation of safety devices requires commitment in personnel to review existing and new SESIP options, and it also requires up-front (and continuous) allocation of resources to purchase devices that offer better protection.

Although not a finding in this study, it has been reported that smaller healthcare facilities lag behind larger ones in adoption of SESIPs. (Hogan, 2005) This is likely due to more limited resources in smaller settings to adequately meet the requirement to conduct SESIP device evaluations. As an option to assist in this process, industry stakeholders such as the AORN, ACS, and the American Nurses Association (ANA) could collaborate with device manufacturers, distributers, and researchers (e.g., through NIOSH- or labor organization-funded projects) to provide an avenue for specialty-based evaluations of available devices. This type of multidisciplinary team could perform trials and regularly update a listing of available devices deemed appropriate for use (by specialty-type) from which employers could select device options for their own internal evaluations. As well, the National Institutes for Occupational Safety and Health (NIOSH) could incorporate a module onto their existing Occupational Health Safety Network (OHSN) that would allow facilities to share information about devices used for different specialties. Facilities could benchmark their own device selection results against those of other facilities and gain information that would otherwise be costly to develop. The internal selection process could thereby be made less burdensome for smaller employers with options such as these.

Our study showed training to be a significant predictor of SESIP needle use. This finding is consistent with previous research. [Osborne, 2003(a); Jeong, 2009; Stringer et al., 2009(b)] More effective and recurring training at the institutional level can have significant effects on compliance. According to the OSHA regulation, employers must offer bloodborne pathogens training in a manner that allows workers access to a person who can answer questions at the time of training. As with the selection of devices, it is also a necessity for organizational leaders to allocate resources needed to effectively train workers. Employers must offer effective training and allow workers the time to participate in the training. Since many facilities now offer more flexible, convenience-type training through electronic media, we recommend further research of training options to assess the various choices and relative effectiveness. Also, many schools of nursing now offer education on bloodborne pathogens to their students, but fewer schools now dedicate much of their curriculum to OR experience. Safety behaviors that are specific to nurses who work in ORs may be less frequently stressed. We suggest the inclusion of such training in the curriculum of all health and allied health training programs.

Beyond the institutional level, one way to improve the enforcement of compliance with the OSHA standard is through stronger enforcement at the Federal government level. When Congress mandated OSHA's change to the BBP standard in 2000, that mandate was not accompanied by an allocation of additional resources for enforcement of the new provisions. Additional resources are needed to increase OSHA staffing, internal training and capability to effectively enforce the standard.

5.5 RECOMMENDATIONS FOR FURTHER RESEARCH

5.5.1 Public support and advocacy

From our research, it appears the likelihood of nurses' use of SESIP needles lies largely with actions of the facilities in which they work—making devices available, implementing mandatory policies to use them, and training on the use of devices are measures that have previously been recommended and are strongly supported by findings of our studies. We would recommend future studies, similar to these, that involve nurses that are not members or AORN as well as surgeons and surgical technicians who also have similar exposures and risks of needlesticks.

We also recommend greater effort on the part of manufacturers in developing new devices that overcome some of the barriers to use. Through further research, enhanced technology, and evidence-based practice, we might be able to document appropriate and successful uses of SESIP needles in place of recapping conventional ones.

The gains from efforts of the past can be augmented through continued collaboration among authoritative governmental entities such as, OSHA, NIOSH, the Centers for Medicare and Medicaid Services (CMS) as well as non-governmental bodies with authority, such as, The Joint Commission (TJC). Although worker safety is not a mission of either the CMS or TJC—both are more focused on patient safety—hospitals are particularly mindful of rules and recommendations that are endorsed by the CMS and TJC. Such collaboration would send a strong message to healthcare organizations about the importance of a strong safety culture that equates the welfare of caregivers with that of patients. The OSHA and NIOSH both have information available on their websites that encourage changes in hospital safety culture and promote awareness that worker safety and patient safety are inextricably linked. Ongoing evaluation of these and other available tools is needed to determine level of use and effectiveness of these resources.

We also encourage additional research to reassess the cost effectiveness of SESIP use with specific analyses within the surgical subsector of healthcare. Illustration of the overall benefits to organizations, including reduction in post-exposure-related costs and increases in productivity by lowering absenteeism and other costs associated with illness, disability, or inability to work due to needlestick injuries, could strongly impact willingness to allocate up-front capital investment in safety measures.

5.6 LIMITATIONS OF THE STUDY

Not unexpectedly, we encountered the issue of a low response rate that is typically seen with nationally distributed electronic surveys. Thus, self-selection into the study may be a source of selection bias. It is not possible to compare those who choose to complete the study to those who do not. This form of selection bias is a concern that is common to many studies that rely on web-based methodology. Although eligibility for participation in this study was not based on any set criteria such as previous history of needlesticks, those who had greater concerns or interest in safety factors may have been more likely to respond. However, all AORN members had an equal chance of falling into the sample population and therefore an equal opportunity to respond. We were able to compare characteristics of the sample population to their organization and showed that respondents were comparable to the overall membership on distribution of age, gender, and job titles. Information bias was also likely if responders provided more positive reports of their own behavior. However, the study was conducted in a manner to maintain anonymity.

We are reminded to be cautious in generalizing findings because nurses represent only one profession on surgical teams. However, many of the factors examined in this study apply to others in surgical settings who may benefit from interventions at the institutional level, such as developing and maintaining policies, providing training, and involving the employees in the selection and introduction of improved safety measures.

We also were able to show a varied distribution of institutions according to size, public versus private affiliation, medical specialties, job titles, and geographic region.

There is also the possibility that institutions may be represented by more than one nurse; thereby providing greater weight to responses that characterize a specific institution. This was unavoidable if respondents were to be assured anonymity, but, again, the variability in institution characteristics suggests a broad representation of places of employment.

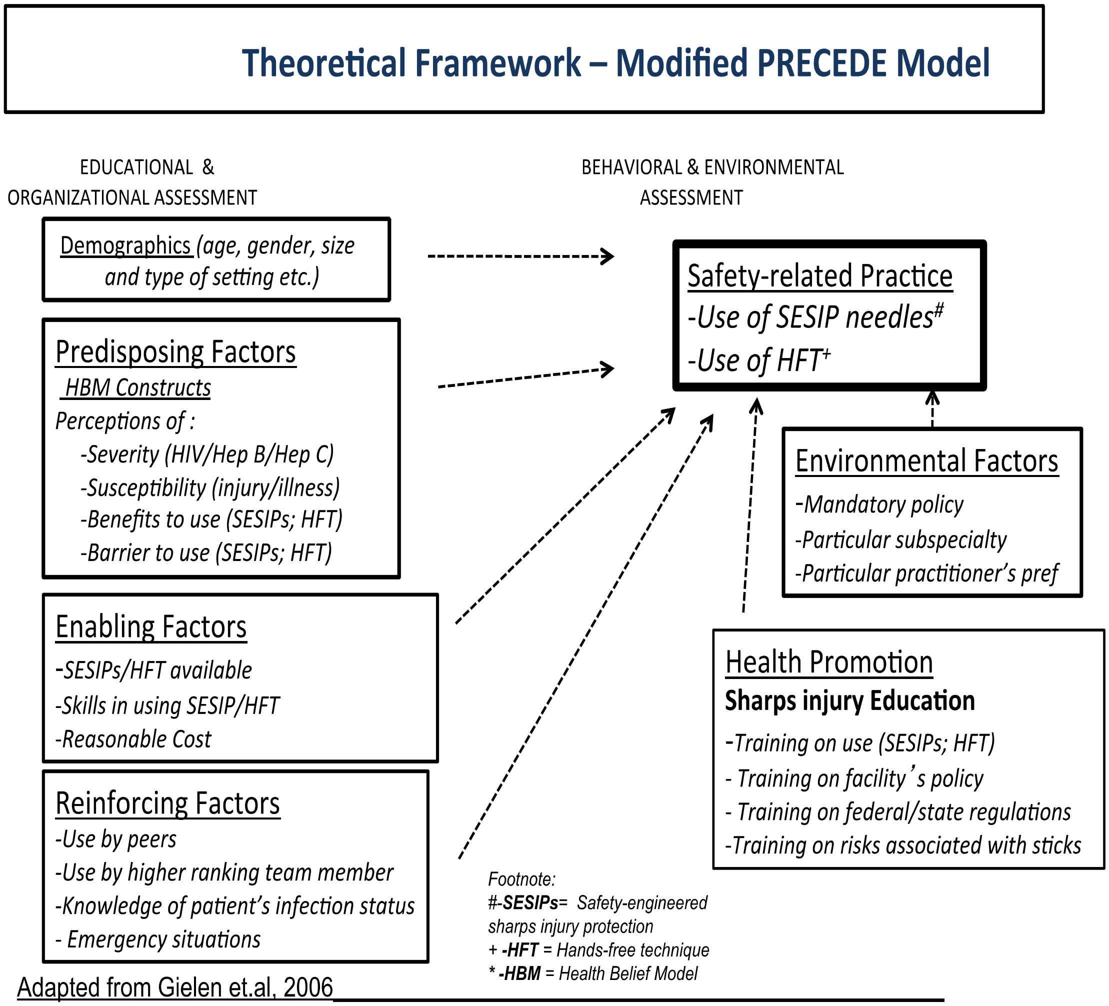
The design of this study, and cooperation of the only professional organization of practicing OR nurses, allowed us to reach a nationwide population that is at risk of serious consequences should safety measures fail or be disregarded. The use of the modified PRECEDE model as a framework to simultaneously analyze these constructs at the individual and organizational level is a novel approach that adds to our current knowledge.

5.7 CONCLUSION

Efforts to develop interventions to increase the use of HFT and SESIP should take into account the primary findings in this study which include: 1) the overall rates of use for SESIP needles and HFT in ORs were low; 2) reported “awareness” of policies mandating use of SESIP needles and HFT was low but was shown to be one of the strongest predictors of use for both safety practices; 3) those who reported certain safety training experiences reported higher rates of HFT or SESIP needle use; 4) lower perceptions of barriers, higher perceptions of benefits and of enabling factors were strong predictors of use; 5) those who had the opportunity to provide input into SESIP selection, and who reported that the entire surgical team contributed to the decision reported significantly higher rates of use; and, 6) rate of use for either SESIP needles or HFT was higher when nurses also reported regular use of other safe work practices (e.g., announcing sharps transfers; refraining from needle recapping), suggesting an influence of safety culture. Many of these findings are consistent with the findings of previous studies (Gershon et al., 1999; Clarke, 2002; Osborne, 2003; Cunningham, 2007; Stringer et al., 2006; Stringer et al., 2009(a); Stringer et al., 2009(b); Jeong, 2008(a), Hagstrom, 2006; Efstathiou, 2011). At the individual level, use of both safety practices were associated with lower perceptions of barriers, and the use of HFT was associated with higher perceptions of benefits. These may be important findings to be considered in obtaining more details of factors of importance to OR nurses. For example, it would be important to find out more about specific barriers that might discourage use. Nurses' perceptions of barriers to use can be influenced by implementation of policies that reduce barriers, and their perceptions of the benefits can be influenced by the development of training that better clarify the benefits of use. The need for better implementation of institutional policies and enhanced training efforts have been highlighted by this study as actions needed at the institutional level. Actions external to the individual and the institution can also have substantial impact on compliance. For instance, greater efforts on the part of manufacturers can result in development of new devices that overcome some of the barriers to use, e.g., the development of more passive devices that further eliminate the need for activation on the part of the users. As well, stronger enforcement and continued collaboration on outreach at the Federal level can ensure better compliance within institutions.

We expect that the findings and recommendations from our research can assist facilities in enhancing the prioritization of interventions aimed at increasing use of safer needles and HFT in the passing of instruments used in OR settings. Building on current understanding of the factors most likely to affect use of safer needles and HFT in the OR is a positive step toward promoting safer policies. There is a pressing need for approaches to promote compliance of not only individuals, but of their institutions as well.

APPENDIX A – Theoretical Framework for Study 2



APPENDIX B – Final Survey Research Tool

1. Demographics

Directions for this section: Unless otherwise indicated, for each item please check the one box that most closely reflects your usual situation.

***1. Age:** ☐Under 25 yrs old ☐25 – 30 yrs old ☐31- 35 yrs old ☐36- 40 yrs old
☐41- 45 yrs old ☐46 - 50 yrs old ☐51 - 55 yrs old ☐56 yrs or older

***2. Sex:** ☐Male ☐Female

***3. Title – Please select the title that closest matches your current position:**
☐Nurse Mgr/Supervisor ☐Hospital/Facility Administrator ☐Director/VP/Ast. Dir
☐Staff Nurse ☐RN First Assistant ☐Clinical Nurse Specialist
☐Not Currently Practicing Nursing

[Skip Pattern Inserted Here to End Survey if "Not* currently practicing nursing"*]

2. Demographics(cont.)

Directions: Unless otherwise indicated, for each item please check the one box that is most applicable.

***1. Time in current position:**
months ________# years ______

***2. Time in organization:**
months ________# years ______

***3. Work category** (select one)**:** ☐full time ☐regular part time ☐PRN

***4. What was your usual shift in the past 12 months:**
☐8 hour/day ☐10 hour/day ☐12 hour /day ☐Other (please specify) _______

***5. How often did you work overtime in the past 12 months:**
☐1 time per month or less
☐ 2-3 times per month
☐4-7 times per month
☐More than 1 time per week

***6. Number of ORs in your facility**: ☐1-5 ☐6-10 ☐11-20 ☐>20

***7. Which best describes the type of facility in which you work:**
☐Private hospital (Teaching) ☐Private hospital (Non-Teaching)
☐Public hospital(Teaching) ☐Public hospital(Non-Teaching)
☐Doctor's Office ☐Outpatient surgical Center ☐Other, please specify ____

***8. Type of city/town in which you work:**

☐Urban ☐Suburban ☐Rural

***9. In what State or U.S. territory do you work: ___________________**

****10. How many reportable sharps injuries have you sustained in the last <u>twelve</u> months? Note: A reportable sharps injury means an injury piercing the skin barrier (such as a needlestick, cut or abrasion) involving a contaminated needle or other contaminated sharp medical device used in your work).***

☐None ☐1 or more

[Skip Pattern Inserted Here so those who select "None" move directly to Section on OR Unit]

3. Reportable sharps injuries

Please respond to the following questions regarding your reportable sharps injury experience(s) – i.e., injuries piercing the skin and involving contaminated sharps devices.

1. Please enter the number of reportable sharps injuries you have sustained in the past twelve months.

\# of reportable sharps injuries ___________

2. Which of the following devices were involved in your reportable sharps injuries? (Check all that apply)

☐Hypodermic needle (i.e., Hollow-bore needle used with a syringe to inject patients)
☐IV Needle
☐Suture Needle
☐Scalpel
☐Other (please specify)___________

4. OR unit

In this survey, think of your operating (OR) unit as the work area, department, service line, or clinical area of the hospital where you spend *most* of your work time or provide *most* of your clinical services. Please select the one box that most closely reflects your usual situation.

1. What is your primary OR unit in this facility?

☐ a. General Surgery
☐ b. Orthopedic Surgery
☐ c. Obstetrics
☐ d. Neurosurgery
☐ e. Opthalmology
☐f. Cardiothoracic
☐g. Otolaryngology
☐ h. Other, please specify:

2. How long have you worked in this OR unit? # months ________# years ______

3. When passing any sharps instruments (e.g., needles, scalpels, saws, etc.) in my OR unit, I announce transfers:
☐Always
☐Usually
☐Half the time
☐Seldom
☐Never

4. When passing sharp instruments (e.g., needles, scalpels, saws, etc.) in my OR unit, I use hands-free passing technique. Note: Hands-free passing technique means a workpractice which eliminates hand-to-hand passing of contaminated instruments during surgery (Stringer, 2002).
☐Always
☐Usually
☐Half the time
☐Seldom
☐Never

***5. Are hypodermic needles (i.e., hollow-bore needle used with a syringe to inject patients) used by surgeons in your OR?**
☐Yes ☐No ☐I don't know

[Skip Pattern Inserted Here if response is no or "I don't know" responder it advances to Sec. on Safety-engineered sharps use]

5. Hypodermic Needle Use

Please answer the following questions regarding needle safety.

1. When hypodermic needles are used by surgeons in my OR unit, I recap them after use:
☐Always
☐Usually
☐Half the time
☐Seldom
☐Never

2. **When hypodermic needles are used by surgeons in your OR unit, what proportion of the time are safety-engineered needles used?** *(Note: Safety-engineered needles are needles with sharps safety feature such as a retractable needle or one with a built-in shield which covers the needle after use)*
☐Always
☐Usually
☐Half the time
☐Seldom
☐Never

3. **Has your current employer provided you training on how to use the safety-engineered hypodermic needles?** ☐Yes ☐No ☐I don't know ☐N/A (we never use SESIP hypodermic needles)

4. Does your employer have a mandatory policy requiring use of safety-engineered hypodermic needles? ☐Yes ☐ No ☐I don't know

6. Safety-engineered sharps use

Please check the one box that most closely reflects your usual situation.

1. Does your OR unit have safety-engineered devices? (Note: Safety-engineered devices are sharp medical devices with a safety feature such as a blunted tip or a built-in shield which covers the sharp after use)
☐Yes ☐No

[Skip Pattern Inserted Here if response is "no" responder advances to Sec. on Training experience]

7. Use of safety-engineered sharps (cont.)

Directions for this section: Unless otherwise indicated, for each item please check the one box that most closely reflects your usual situation.

1. Who decides whether safety-engineered devices are used in your OR unit?
☐Surgeon(s)
☐Nurse manager
☐Safety officer/infection control specialist
☐Scrub nurse
☐Entire surgical team
☐I don't know
☐Other, please specify _____________

2. Do you provide input into the process for selecting the safety-engineered devices used in your OR unit? ☐Yes ☐No

3. Do you have peers (i.e., other nurses) who provide input into the process for selecting the safety-engineered devices used in your OR unit? ☐Yes ☐No ☐I don't know

4. Does your current employer provide you training each time a new safety-engineered device is selected for use in your OR unit?
☐Always
☐Usually
☐Half the time
☐Seldom
☐Never

8. Training experience

Directions for this section: Unless otherwise indicated, for each item please check the one box that most closely reflects your usual situation.

1. **Has your current employer provided you training on the OSHA requirements relating to sharps safety, within the past 12 months?**
☐ Yes ☐No ☐I don't know

2. **Has your current employer provided you training on how the risks associated with sharps injuries in your OR, within the past 12 months?** ☐Yes ☐No ☐I don't know

3. **Has your current employer provided you training on the facility's policies related to sharps safety, within the past 12 months?**
☐ Yes ☐No ☐I don't know

4. **Has your current employer trained you on the use of hands-free passing techniques in your OR unit**? ☐Yes ☐No ☐I don't know

5. **Does your employer have a mandatory policy requiring use of hands-free passing of instruments?** ☐Yes ☐No ☐ I don't know

9. Other work practice experience

Directions for this section: Unless otherwise indicated, for each item please check the one box that most closely reflects your level of agreement with each statement below.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
1. My chance of getting Hep B, Hep C or HIV at work is high	☐1	☐2	☐3	☐4	☐5	
2. I have contact with many patients infected with Hep B, Hep C or HIV at work	☐1	☐2	☐3	☐4	☐5	
3. There is very little chance that I will get Hep B, Hep C or HIV from my work	☐1	☐2	☐3	☐4	☐5	
4. If I get Hep B, Hep C or HIV my career would be endangered	☐1	☐2	☐3	☐4	☐5	
5. If I get Hep B, Hep C or HIV, my financial security would be endangered	☐1	☐2	☐3	☐4	☐5	
6. If I get Hep B, Hep C or HIV, a significant relationship in my life would be endangered	☐1	☐2	☐3	☐4	☐5	
7. Using safety-engineered hypodermic needles decreases my risk of acquiring Hep B, C/HIV	☐1	☐2	☐3	☐4	☐5	
8. I am very skilled in the use of safety-engineered hypodermic needles in procedures in my OR	☐1	☐2	☐3	☐4	☐5	☐N/A
9. Safety-engineered hypodermic needles interfere with many procedures performed in my OR	☐1	☐2	☐3	☐4	☐5	☐N/A
10. Safety-engineered hypodermic needles are supplied in my OR	☐1	☐2	☐3	☐4	☐5	☐N/A
11. Safety-engineered hypodermic needles are too expensive to use	☐1	☐2	☐3	☐4	☐5	

Strongly **Strongly**

	Agree	Agree	Neutral	Disagree	Disagree	
12. Supplies of safety-engineered hypodermic needles are limited supply at my facility	☐1	☐2	☐3	☐4	☐5	☐N/A
13. Safety-engineered hypodermic needles are too time consuming to use all the time	☐1	☐2	☐3	☐4	☐5	☐N/A
14. My use of safety-engineered hypodermic needles is determined by the surgeon's preference	☐1	☐2	☐3	☐4	☐5	☐N/A
15. I am more likely to use safety-engineered hypodermic needles if my peers also use them	☐1	☐2	☐3	☐4	☐5	
16. I am more likely to use safety-engineered hypodermic needles if a senior member of my team uses them	☐1	☐2	☐3	☐4	☐5	
17. I am more likely to use safety-engineered hypodermic needles when the patient is known to be infected with Hep B, Hep C or HIV	☐1	☐2	☐3	☐4	☐5	☐N/A
18. Safety-engineered needles interfere with administering incremental doses of anesthetics	☐1	☐2	☐3	☐4	☐5	☐N/A
19. Safety-engineered hypodermic needles do not interfere with patient safety	☐1	☐2	☐3	☐4	☐5	
20. I am less likely to use safety-engineered hypodermic needles if I am able to use the hands-free passing technique	☐1	☐2	☐3	☐4	☐5	☐N/A
21. Using a hands-free passing technique decreases my risk of acquiring Hep B, Hep C or HIV	☐1	☐2	☐3	☐4	☐5	
22. I am very skilled in the use of the hands-free passing of sharps during procedures in my OR	☐1	☐2	☐3	☐4	☐5	
23. The hands-free passing technique interferes with many procedures performed in my OR	☐1	☐2	☐3	☐4	☐5	
24. Supplies of equipment for use in hands-free passing (e.g., magnetic rubber mats) are limited in my OR	☐1	☐2	☐3	☐4	☐5	
25. I am more likely to use the hands-free passing technique if a senior member of my team uses it	☐1	☐2	☐3	☐4	☐5	

Strongly **Strongly**

	Agree	Agree	Neutral	Disagree	Disagree
26. I am more likely to use the hands-free passing technique when the patient is known to be infected with Hep B, Hep C or HIV	☐1	☐2	☐3	☐4	☐5
27. My use of the hands-free passing technique is determined by the surgeon's preference	☐1	☐2	☐3	☐4	☐5
28. Hands-free passing technique is too time consuming to use all the time	☐1	☐2	☐3	☐4	☐5
29. I am less likely to use the hands-free passing technique when the procedure is an emergency case	☐1	☐2	☐3	☐4	☐5

END OF SURVEY
Thank you for taking the time to complete this survey

APPENDIX C – PRECEDE Categorization of Survey Questions

[Demographics (Sec I) Questions]
Age; Gender; Title
Time in current position; in Specialty; in Organization
No. ORs in your facility
Work category (full time/PT/Per diem)
Type of Facility (Hospital/Teaching/Non-Teaching/Inpatient/Outpatient)
Type of City/town (Urban/Suburban/Rural)
State/territory where work
No . of sharps injuries in the last <u>twelve</u> months

Demographics

Q9.1 My chance of getting Hep B/Hep C/HIV is high
Q9.2 I contact many patients infected w/ Hep B/Hep C/HIV
Q9.3 There is little chance I will get Hep B/Hep C/HIV from work

Susceptibility Items

Q9.4 If I get Hep B/Hep C or HIV, my career would be endangered
Q9.5 If I get Hep B/Hep C or HIV, my financial security would be endangered
Q9.6 If I get Hep B/Hep C or HIV, a significant relationship in my life would be endangered

Severity Items

<u>SESIP needle use</u>
Q9.7 Using SE hypodermic needle decreases my risk of acquiring Hep B/Hep C/HIV
<u>Hands-free Technique (HFT)</u>
Q9.21 Using a HFT decreases my risk of acquiring Hep B/Hep C/HIV

Benefit Item(s)

<u>SESIP needle use</u>
Q9.9 SESIP hypodermic needles interfere with many procedures performed in my OR
Q9.13 SESIP syringes too time consuming to always use
Q9.18 SESIP needles interfere with administering incremental doses of anesthetics
<u>Hands-free Technique (HFT)</u>
Q9.23 HFT interfere with many procedures performed in my OR
Q9.28 HFT is too time consuming to always use

Barrier Items

Predisposing Factors

SESIP needle use

Q9.8 I am very skilled in the use of SESIP hypodermic needles in the procedures in my OR

Q9.11 Safety-engineered hypodermic needles are too expensive

Q9.10 Safety-engineered hypodermic needles are supplied in my OR

Q9.12 SESIP syringes are in limited supply at my facility

Hands-free Technique (HFT)

Q9.22 I am very skilled in the use of the HFT

Q9.24 Supplies of equipment for use of HFT (e.g., magnet mats) are limited in my OR

Enabling Factors

SESIP needle use

Q9.15 I am more likely to use safety-engineered hypodermic needles if my peers also use them

Q9.16 I am more likely to use safety-engineered hypodermic needles if a senior member of my team uses them

Q9.17 I am more likely to use safety-engineered (SESIP) needles when patient is known to be infected with Hep B/Hep C/HIV

Hands-free Technique (HFT)

Q9.25 I am more likely to use the hands-free passing technique if a senior member of my team uses

Q9.26 I am more likely to use hands-free passing technique (HFT) when patient is known to be infected with Hep B/C/HIV

Q9.29 I am less likely to use the hands-free passing technique when the procedure is an emergency case

Reinforcing Factors

SESIP needle use

Q5.4 Employer has a mandatory policy requiring use of safety-engineered hypodermic needles

Hands-free Technique (HFT)

Q8.5 Employer has a mandatory policy requiring use of hands-free passing of instruments

Environmental Factors

Items used to assess training experiences

Q5.3 Current employer provided me training on how to use new SESIP needles
Q7.4 Current employer provided me training each time a new SESIP device is selected for use
Q8.1 Current employer provided me training on the OSHA requirements relating to sharps-safety w/in past 12 mths
Q8.2 My current employer provided me training on the risks associated with sharps injuries in my OR w/in past 12 mths
Q8.3 My current employer provided me training on the facility's policies related to sharps safety w/in past 12 mths
Q8.4 Current employer provided me training on use of hands-free passing techniques in my OR unit

Training

Additional items gathered from the survey

Q4.5 Are hypodermic needles used in your OR*
Q4.3 When passing sharps, I announce sharps transfers
Q5.1 When hypodermic needles used, I recap them after use
Q6.1 Does your OR have safety-engineered devices*
Q7.1 Who decides whether safety-engineered devices are used in your OR
Q7.2 Do you provide input in process of selecting SESIP devices in your OR
Q7.3 Do your peers provide input in process of selecting SESIP devices in your OR
Q9.19 SESIP hypodermic needles do not interfere with patient safety
Q9.20 I would be less likely to use safety-engineered needles if I was able to use hands-free passing techniques
Q9.14 My use of SESIP hypodermic needles is determined by the surgeon's preference
Q9.27 My use of HFT is determined by the surgeon's preference

Miscellaneous Safety Practices

Dependent Variables:

Q4.4 When passing sharps, how often is HFT used in my OR
Q5.2 When hypodermic needles used, how often are safety-engineered needles used?

*NOTE: The questions concerning whether hypodermic needles are used and whether SESIP devices are available in in one's OR determined respondents' eligibility to participate in analyses related to outcomes about SESIP needles.

APPENDIX D – Supplemental Tables for Manuscript 1

Table Appendix D 1 Demographic characteristics of study population and AORN membership

Demographic variable	Study Sample (%)	AORN Membership (%)
Gender		
Male	9	8
Female	91	92
Age		
≤ 30 years old	5	5
31- 40 years old	14.99	12.00
41- 45 years old	11.71	9.18
46 - 50 years old	14.29	14.63
51 - 55 years old	23.19	21.70
≥56 years or older	30.91	37.5
Job title (dichotomized)		
Non-managers	84	84
Managers	16	16

Table Appendix D 2 Compliance with OSHA requirements

OSHA Requirements (29 CFR 1910.1030)	Compliance Rate
1910.1030(d)(2)(i) – Use of SESIP needles / good work practices	
Use of SESIP needles	46%
Use of HFT	42%
Announce sharps transfer	70%
1910.1030(c) – Facility has mandatory policy	
Awareness of a mandatory policy to use SESIP needles*	43%
Awareness of a mandatory policy to use HFT*	22%
1910.1030(c)(2)(v) – Solicit employee input in SESIP selection	
Providing input in SESIP selection	66%
1910.1030(d)(2)(vii)(A) – Prohibited recapping	
Avoid recapping used needles (*safer* work practice)	55%
1910.1030(g) – Employee Training	
Trained on use of SESIPs	84%
Trained on use of HFT	65%
Trained on: OSHA requirements; risks assoc. w/ injuries; facility policies	69 – 73%

*In an effort to maintain anonymity, an item was used to represent the nurses' "awareness" of a mandatory policy in lieu of actual information about existence of a policy in specific facilities.

Table Appendix D 3 Correlation matrix of associations between demographic variables with HFT use

	HFT use	Age	Gender	Job Title	Time-in-job
Age	-0.0310	1.0000			
Gender	0.0944	0.0604	1.0000		
Job Title	**0.1922**	0.0530	-0.0231	1.0000	
Time-in-job	**-0.1109**	**0.3571**	0.0875	**-0.1737**	1.0000

Pearson's correlation matrix (*r*) **Bold = p<0.05**

Table Appendix D 4 Correlation matrix of associations between demographic variables and SESIP needle use

	SESIP needle use	Age	Gender	Job Title	Time-in-job
Age	0.1055	1.0000			
Gender	-0.0381	0.0910	1.0000	1.0000	
Job Title	0.1087	0.0607	-0.0495	1.0000	
Time-in-job	-0.0701	**0.3705**	0.0577	**-0.1448**	1.0000

Pearson correlation matrix (*r*) **Bold = p<0.05**

Table Appendix D 5 Adjusted logistic regression models of associations between demographics and HFT use (n=427)

Variable	Bivariate Model+ OR	95% CI	Multivariate Model (adjusted) OR	95% CI
Gender				
Male	reference		reference	
Female	2.09	(0.98 - 4.43)	**2.41**	**(1.11 – 5.24)**§
Job Title				
Non-managers	reference		reference	
Managers	**2.87**	**(1.68 - 4.91)**§§	**2.71**	**(1.56 – 4.70)**§§
Time-in-job				
1-12 months	reference		reference	
13-60 months	1.22	(0.58 - 2.53)	1.26	(0.59 – 2.72)
61-120 months	1.33	(0.60 – 2.95)	1.38	(0.60 – 3.17)
121-240 months	1.00	(0.45 – 2.23)	1.15	(0.50 – 2.65)
>240 months	0.53	(0.23 – 1.21)	0.59	(0.25 – 1.41)

+Crude bivariate logistic regression Multivariate logistic model; includes the use of HFT adjusted for gender, job title and time-in-job **Bold** is significant §Significant results: p<0.05); §§Significant results, p<0.001

Table Appendix D 6 Adjusted logistic regression models of associations between demographics and SESIP needle use (n=306)

Variable	Bivariate Model+ OR	95% CI	Multivariate Model (adjusted) OR	95% CI
Gender				
Male	reference		reference	
Female	0.76	(0.35 - 1.69)	0.80	(0.36 – 1.80)
Job Title				
Non-managers	reference		reference	
Managers	1.80	(0.97 - 3.33)	1.69	(0.90 – 3.15)
Time-in-job				
1-12 months	reference		reference	
13-60 months	0.95	(0.39 – 2.32)	0.95	(0.39 – 2.35)
61-120 months	1.37	(0.53 – 3.59)	1.39	(0.53 – 3.66)
121-240 months	0.72	(0.27 – 1.92)	0.74	(0.27 – 1.99)
>240 months	0.67	(0.25 – 1.80)	0.74	(0.28 – 2.00)

+Crude bivariate logistic regression Multivariate logistic model; includes the use of SESIP needles adjusted for gender, job title & time-in-job

Table Appendix D 7 Fisher's exact test showing associations between demographic variables and HFT use

Demographic Variable	Overall n(%) 427 (100%)	HFT nonuser n(%) 247 (57.85%)	HFT user$^{\gamma}$ n(%) 180 (42.15%)	Fisher's exact (p-value)
Age				
≤ 30 years old	21 (4.92)	14 (66.67)	7 (33.33)	(p=0.774)
31- 40 years old	64 (14.99)	33 (51.56)	31 (48.44)	
41- 45 years old	50 (11.71)	29 (58.00)	21 (42.00)	
46 - 50 years old	61 (14.29)	34 (55.74)	27 (44.26)	
51 - 55 years old	99 (23.19)	56 (56.57)	43 (43.43)	
≥56 years or older	132 (30.91)	81 (61.36)	51 (38.64)	
Gender				
Male	37 (8.67)	27 (72.97)	10 (27.03)	(p=0.056)
Female	390 (91.33)	220 (56.41)	170 (43.59)	
Employment status				
Part-Time	49 (11.48)	34 (69.39)	15 (30.61)	(p=0.073)
Full-Time	368 (86.18)	205 (55.71)	163 (44.29)	
PRN	10 (2.34)	8 (80.00)	2 (20.00)	
Type of Facility				
Private Hospital	171 (40.05)	102 (59.65)	69 (40.35)	(p=0.892)
Public Hospital	169 (39.58)	96 (56.80)	73 (43.20)	
Outpatient Surgical Center	73 (17.10)	39 (53.42)	34 (46.58)	
Doctor's Office/Other	14 (3.28)	10 (71.43)	4 (28.57)	

Fisher's Exact Test Results

Table Appendix D 8 Fisher's exact test showing associations between demographic variables and SESIP needle use

Demographic Variable	Overall n(%) 306* (100%)	SESIP needle nonuser n(%) 166 (54.25%)	SESIP needle user$^{\gamma}$ n(%) 140 (45.75%)	Fisher's exact (p-value)
Age				
≤ 30 years old	15 (4.90)	12 (80.00)	3 (20.00)	(p=0.325)
31- 40 years old	47 (15.36)	28 (59.57)	19 (40.43)	
41- 45 years old	32 (10.46)	16 (50.00)	16 (50.00)	
46 - 50 years old	50 (16.34)	28 (56.00)	22 (44.00)	
51 - 55 years old	67 (21.90)	35 (52.24)	32 (47.76)	
≥56 years or older	95 (31.05)	47 (49.47)	48 (50.53)	
Gender				
Male	27 (8.82)	13 (48.15)	14 (51.85)	(p=0.548)
Female	279 (91.18)	153 (54.84)	126 (45.16)	
Employment status				
Part-Time	31 (10.13)	15 (9.04)	16 (11.43)	(p=0.058)
Full-Time	269 (87.91)	145 (87.35)	124 (88.57)	
PRN	6 (1.96)	6 (3.61)	0 (0.00)	
Type of Facility				
Private Hospital	126 (41.18)	68 (40.96)	58 (41.43)	(p=0.905)
Public Hospital	121 (39.54)	65 (39.16)	56 (40.00)	
Outpatient Surgical Center	47 (15.36)	25 (15.06)	22 (15.71)	
Doctor's Office/Other	12 (3.92)	8 (4.82)	4 (2.86)	
OR unit worked				
General Surgery	102 (33.33)	62 (37.35)	40 (28.57)	**(p=0.013)**
Orthopedic Surgery	81 (26.47)	33 (19.88)	48 (34.29)	
Cardiothoracic & Obstetrics	15 (4.90)	5 (3.01)	10 (7.14)	
Neuro/Opthal/Otolaryngology	33 (10.78)	19 (11.45)	14 (10.00)	
Multidisciplinary	75 (24.51)	47 (28.31)	28 (20.00)	

Fisher's Exact Test Results **Bold** is significant p<0.05

APPENDIX E – Supplemental Tables for Manuscript 2

Table Appendix E 1.1 Associations of PREDISPOSING Precede Factor items with SESIP needle use (n=306)*

Survey Item	SESIP nonuser n (%)	SESIP user n (%)	p-value
Predisposing Factors (HBM Construct Items)			
Susceptibility Items			
- My chance of getting infected Hep B, C/HIV at work			0.121
Strongly Disagree	12 (7.23)	7 (5.00)	
Disagree	33 (19.88)	33 (23.57)	
Neutral	38 (22.89)	19 (13.57)	
Agree	48 (28.92)	55 (39.29)	
Strongly Agree	35 (21.08)	26 (18.57)	
- I have contact with many patients infected with Hep B, C/HIV			0.865
Strongly Disagree	13 (7.83)	10 (7.14)	
Disagree	34 (20.48)	33 (23.57)	
Neutral	33 (19.88)	23 (16.43)	
Agree	53 (31.93)	42 (30.00)	
Strongly Agree	33 (19.88)	32 (22.86)	
- There's little chance I'll get HepB, C/HIV from work $^{\Omega}$			0.741
Strongly Agree	8 (4.82)	8 (5.71)	
Agree	35 (21.08)	37 (26.43)	
Neutral	63 (37.95)	45 (32.14)	
Disagree	42 (25.30)	33 (23.57)	
Strongly Disagree	18 (10.84)	17 (12.14)	
Severity Items			
- If I get Hep B/Hep C or HIV, my career would be endangered			0.902
Strongly Disagree	3 (1.81)	4 (2.86)	
Disagree	23 (13.86)	16 (11.43)	
Neutral	20 (12.05)	15 (10.71)	
Agree	59 (35.54)	49 (35.00)	
Strongly Agree	61 (36.75)	56 (40.00)	
- If I get Hep B/Hep C or HIV, my financial security would be endangered			
Strongly Disagree	3 (1.81)	1 (0.71)	0.799
Disagree	10 (6.02)	11 (7.86)	
Neutral	16 (9.64)	10 (7.14)	
Agree	63 (37.95)	54 (38.57)	
Strongly Agree	74 (44.58)	64 (40.00)	
- If I get Hep B/Hep C or HIV, a significant relationship in my life would be endangered			
Strongly Disagree	7 (4.22)	9 (6.43)	
Disagree	22 (13.25)	20 (14.29)	0.730
Neutral	21 (12.65)	12 (8.57)	
Agree	47 (28.31)	42 (30.00)	
Strongly Agree	69 (41.57)	57 (40.71)	
Benefit *(SESIP needle use)* Item			
- Using safety-engineered hypodermic needle decreases my risk of acquiring Hep B/Hep C/HIV			0.102
Strongly Disagree	3 (1.81)	2 (1.43)	
Disagree	4 (2.41)	5 (3.57)	
Neutral	25 (15.06)	8 (5.71)	
Agree	54 (32.53)	45 (32.14)	

Strongly Agree	80 (48.19)	80 (57.14)	
Barrier *(SESIP needle use)* Items			
- SESIP hypodermic needles interfere with many procedures performed in my OR$^{\Omega}$			**<0.001**
Strongly Agree	18 (10.84)	2 (1.43)	
Agree	44 (26.51)	23 (16.43)	
Neutral	31 (18.67)	33 (23.57)	
Disagree	60 (36.14)	59 (42.14)	
Strongly Disagree	13 (7.83)	23 (16.43)	
- SESIP syringes too time consuming to always use $^{\Omega}$			**<0.001**
Strongly Agree	3 (1.81)	1 (0.71)	
Agree	20 (12.05)	5 (3.57)	
Neutral	50 (30.12)	13 (9.29)	
Disagree	57 (34.34)	65 (46.43)	
Strongly Disagree	36 (21.65)	56 (40.00)	
- SESIP needles interfere with administering incremental doses of anesthetics $^{\Omega}$			0.056
Strongly Agree	11 (6.63)	4 (2.86)	
Agree	25 (15.06)	15 (10.71)	
Neutral	50 (30.12)	36 (25.71)	
Disagree	61 (36.75)	54 (38.57)	
Strongly Disagree	19 (11.45)	31 (22.14)	

*n=306 because the 14 participants who did not use hypodermic needles did not qualify to be safe needle users.
$^{\Omega}$ Responses were reverse-coded so that "Strongly Agree" got 0-points and "Strongly Disagree" got 4-points
$^{\partial}$Chi Squared test **Bold** is significant

Table Appendix E 1.2 Associations of PREDISPOSING Precede Factor items with use of HFT (n=427)

Survey Item	HFT nonuser n (%)	HFT user n (%)	p-value
Predisposing Factors (HBM Construct Items)			
Susceptibility items			
- My chance of getting infected Hep B, C/HIV at work			0.227
Strongly Disagree	17 (6.88)	7 (3.89)	
Disagree	59 (23.89)	36 (20.00)	
Neutral	48 (19.43)	28 (15.56)	
Agree	80 (32.39)	68 (37.78)	
Strongly Agree	43 (17.41)	41 (22.78)	
- I have contact with many patients infected with Hep B, C/HIV			**<0.01**
Strongly Disagree	10 (4.05)	19 (10.56)	
Disagree	73 (29.55)	36 (20.00)	
Neutral	47 (19.03)	27 (15.00)	
Agree	73 (29.55)	54 (30.00)	
Strongly Agree	44 (17.81)	44 (24.44)	0.276
- There's little chance I'll get HepB, C/HIV from work$^{\Omega}$			
Strongly Agree	8 (3.24)	13 (7.22)	
Agree	55 (22.27)	45 (25.00)	
Neutral	86 (34.82)	63 (35.00)	
Disagree	66 (26.72)	41 (22.78)	
Strongly Disagree	32 (12.96)	32 (10.00)	
Severity Items			
- If I get Hep B/Hep C or HIV, my career would be endangered			0.187
Strongly Disagree	5 (2.02)	4 (2.22)	
Disagree	22 (8.91)	30 (16.67)	
Neutral	31 (12.55)	18 (10.00)	
Agree	91 (36.84)	62 (34.44)	
Strongly Agree	98 (39.68)	66 (36.67)	0.924

- If I get Hep B/Hep C or HIV, my financial security would be endangered			
Strongly Disagree	2 (0.81)	3 (1.67)	
Disagree	13 (5.26)	11 (6.11)	
Neutral	25 (10.12)	17 (9.44)	
Agree	96 (38.87)	71 (39.44)	
Strongly Agree	111 (44.94)	111 (43.33)	0.664
- If I get Hep B/Hep C or HIV, a significant relationship in my life would be endangered			
Strongly Disagree	12 (4.86)	9 (5.00)	
Disagree	34 (13.77)	25 (13.89)	
Neutral	35 (14.17)	17 (9.44)	
Agree	68 (27.53)	56 (31.11)	
Strongly Agree	98 (39.68)	73 (40.56)	
Benefit (*Hands-free Technique - HFT)* Item			
- Using the HFT decreases my risk of acquiring Hep B/Hep C/HIV			**<0.001**
Strongly Disagree	4 (1.62)	0 (0.00)	
Disagree	18 (7.29)	2 (1.11)	
Neutral	31 (12.55)	10 (5.56)	
Agree	122 (49.39)	88 (48.89)	
Strongly Agree	72 (29.15)	72 (44.44)	
Barrier Scale (*Hands-free Technique - HFT)* Items			
- HFT interfere with many procedures performed in my OR$^{\Omega}$			**<0.001**
Strongly Agree	13 (5.26)	7 (3.89)	
Agree	57 (23.08)	15 (8.33)	
Neutral	74 (29.96)	38 (21.11)	
Disagree	82 (33.20)	87 (48.33)	
Strongly Disagree	21 (8.50)	21 (18.33)	
- HFT is too time consuming to always use $^{\Omega}$			
Strongly Agree	19 (7.69)	1 (0.56)	**<0.001**
Agree	44 (17.81)	15 (8.33)	
Neutral	67 (27.13)	25 (13.89)	
Disagree	95 (38.46)	100 (55.56)	
Strongly Disagree	22 (8.91)	39 (21.67)	

$^{\gamma}$ HFT users included those who use *Usually* and *Always*; those who use *Half-time/Seldom/Never* are HFT non-users
$^{\Omega}$ Responses were reverse-coded so that "Strongly Agree" got 0-points and "Strongly Disagree" got 4-points
Chi Squared test **Bold** is significant

Table Appendix E 2.1 Associations of ENABLING Precede Factor items with use of SESIP needles (n=306)

Survey Item	SESIP nonuser n (%)	SESIP user n (%)	p-value
Enabling Factors *(SESIP needle use)* Items			
- I am skilled in use of SESIP needle			**<0.001**
Strongly Disagree	2 (1.20)	0 (0.00)	
Disagree	29 (17.47)	0 (0.00)	
Neutral	39 (23.49)	9 (6.43)	
Agree	63 (37.95)	64 (45.71)	
Strongly Agree	33 (19.88)	67 (47.86)	
- SESIP needles are supplied in my OR			**<0.001**
Strongly Disagree	11 (6.63)	0 (0.00)	
Disagree	26 (15.66)	2 (1.43)	
Neutral	20 (12.05)	6 (4.29)	
Agree	79 (47.59)	57 (40.71)	
Strongly Agree	30 (18.07)	75 (53.57)	
- SESIP needles are too expensive to use [Ω]			**<0.001**
Strongly Agree	1 (0.60)	0 (0.00)	
Agree	6 (3.61)	3 (2.14)	
Neutral	79 (47.59)	30 (21.43)	
Disagree	50 (30.12)	59 (42.14)	
Strongly Disagree	30 (18.07)	30 (34.29)	
- Supplies of SESIP needles are limited at my facility[Ω]			**<0.001**
Strongly Agree	21 (12.65)	2 (1.43)	
Agree	44 (26.51)	8 (5.71)	
Neutral	26 (15.66)	14 (10.00)	
Disagree	52 (31.33)	54 (38.57)	
Strongly Disagree	23 (13.86)	62 (44.29)	

SESIP needle users included those who use *Usually* and *Always*; those who use *Half-time*/*Seldom*/*Never* are HFT non-users
*n=306 because the 14 participants who did not use hypodermic needles did not qualify to be safe needle users.
Chi Squared test; **Bold** is significant

Table Appendix E 2.2 Associations of ENABLING Precede Factor items with use of HFT (n=427)

Survey Item	HFT nonuser n (%)	HFT user n (%)	p-value
Enabling Factors (*Hands-free Technique - HFT)* Items			
- I am skilled in use of HFT			**<0.001**
Strongly Disagree	7 (4.19)	1 (0.38)	
Disagree	38 (22.75)	7 (2.69)	
Neutral	65 (38.92)	53 (20.38)	
Agree	46 (27.54)	122 (46.92)	
Strongly Agree	11 (6.59)	77 (29.62)	
- Supplies for HFT are limited at my facility[Ω]			**<0.001**
Strongly Agree	27 (16.17)	23 (8.85)	
Agree	47 (28.14)	41 (15.77)	
Neutral	24 (14.37)	35 (13.46)	
Disagree	55 (32.93)	117 (45.00)	
Strongly Disagree	14 (8.38)	44 (16.92)	

[7] HFT users included those who use *Usually* and *Always*; those who use *Half-time*/*Seldom*/*Never* are HFT non-users
Chi Squared test; **Bold** is significant

Table Appendix E 3.1 Associations of REINFORCING Precede Factor items with use of SESIP needles (n=306)

Survey Item	SESIP nonuser n (%)		SESIP user n (%)		p-value
Reinforcing Factors *(SESIP needle use)* Items					
- I am more likely to use SESIP needles if my peers use them					0.173
Strongly Disagree	24	(14.46)	34	(24.29)	
Disagree	45	(27.11)	32	(22.86)	
Neutral	46	(27.71)	29	(20.71)	
Agree	37	(22.29)	30	(21.43)	
Strongly Agree	14	(8.43)	15	(10.71)	0.070
- I am more likely to use SESIP needles if a senior team member uses them	21	(12.65)	34	(24.29)	
Strongly Disagree	40	(24.10)	30	(21.43)	
Disagree	52	(31.33)	32	(22.86)	
Neutral	38	(22.89)	28	(20.00)	
Agree	15	(9.04)	16	(11.43)	
Strongly Agree					0.112
- I am more likely to use SESIP needles if the patient is infected w/ HIV/Hep B,C					
Strongly Disagree	12	(7.23)	18	(12.86)	
Disagree	32	(19.28)	24	(17.14)	
Neutral	32	(19.28)	16	(11.43)	
Agree	46	(27.71)	34	(24.29)	
Strongly Agree	44	(26.51)	48	(34.29)	

SESIP needle users included those who use *Usually* and *Always*; those who use *Half-time*/*Seldom/Never* are HFT non-users
Chi Squared test

Table Appendix E 3.2 Associations of REINFORCING Precede Factor items with use of HFT (n=427)

Survey Item	HFT nonuser n (%)		HFT user n (%)		p-value
Reinforcing Factors (*Hands-free Technique - HFT)* Items					
- I am more likely to use HFT if a senior team member uses them					0.489
Strongly Disagree	24	(9.72)	19	(10.56)	
Disagree	77	(31.17)	53	(29.44)	
Neutral	80	(32.39)	49	(27.22)	
Agree	48	(19.43)	38	(21.11)	
Strongly Agree	18	(7.29)	21	(11.67)	
- I am more likely to use HFT if the patient is infected w/ HIV/Hep B,C					0.335
Strongly Disagree	10	(4.05)	10	(5.56)	
Disagree	41	(16.60)	28	(15.56)	
Neutral	44	(17.81)	27	(15.00)	
Agree	86	(34.82)	52	(28.89)	
Strongly Agree	66	(26.72)	63	(35.00)	
- I am less likely to use HFT in an emergency $^{\Omega}$					**<0.001**
Strongly Agree	31	(12.55)	19	(10.56)	
Agree	90	(36.44)	39	(21.67)	
Neutral	77	(31.17)	36	(20.00)	
Disagree	39	(15.79)	64	(35.56)	
Strongly Disagree	10	(4.05)	22	(12.22)	

$^{\Upsilon}$ HFT users included those who use *Usually* and *Always*; those who use *Half-time*/*Seldom/Never* are HFT non-users
Chi Squared test; **Bold** is significant

Table Appendix E 4.1 Association of ENVIRONMENT Precede Factor item with use of SESIP needles (n=306)

Survey Item	SESIP nonuser n (%)	SESIP user n (%)	p-value
Environmental Factor (*SESIP needle use)*			
- Employer has mandatory policy to use SESIP needles			**<0.001**
No	98 (59.04)	18 (12.86)	
Yes	68 (40.96)	122 (87.14)	

SESIP needle users included those who use *Usually* and *Always*; those who use *Half-time*/*Seldom/Never* are HFT non-users
Chi Squared test; **Bold** is significant

Table Appendix E 4.2 Association of ENVIRONMENT Precede Factor item with HFT (n=427)

Survey Item	HFT nonuser n (%)	HFT user n (%)	p-value
Environmental Factor (*HFT use)*			
- Employer has mandatory policy to use HFT			**<0.001**
No	226 (91.50)	109 (60.56)	
Yes	21 (8.50)	71 (39.44)	

$^{\gamma}$ HFT users included those who use *Usually* and *Always*; those who use *Half-time*/*Seldom/Never* are HFT non-users
Chi Squared test; **Bold** is significant

CORRELATION MATRICES – Predisposing factors (HBM Constructs)

Table Appendix E 5.1 Correlation matrix of associations between HBM constructs and use of SESIP needles (n=306)

	SESIP needle use	Risk	Severity	Barriers	Benefits
SESIP needle use	1.0000				
Susceptibility	0.0086	1.0000			
Severity	0.0282	**0.2904**	1.0000		
Barriers *(SESIP needle)*	**0.2159**	**0.0947**	-0.0423	1.0000	
Benefits *(SESIP needle)*	0.0893	**0.1447**	**0.2054**	**0.2330**	1.0000

Used the dichotomized summated scale scores Results show Pearson's *r* **Bold -** significant p<0.05

Table Appendix E 5.2 Correlation matrix of associations between HBM constructs and use of HFT (n=427)

	HFT use	Risk	Severity	Barriers	Benefits
HFT use	1.0000				
Susceptibility	0.0140	1.0000			
Severity	0.0122	**0.2995**	1.0000		
Barriers *(HFT)*	**0.2909**	**0.1082**	-0.0182	1.0000	
Benefits *(HFT)*	**0.2033**	**0.1156**	**0.1388**	**0.1882**	1.0000

Used the dichotomized summated scale scores Results show Pearson's *r* **Bold -** significant p<0.05

CORRELATION MATRICES – Remaining PRECEDE Factors

Table Appendix E 6.1 Correlation matrix of associations between 3-PRECEDE Factors and SESIP needle use

	SESIP needle use	Enabling	Reinforcing	Environment
SESIP needle use	1.0000			
Enabling *(SESIP needle)*	**0.4639**	1.0000		
Reinforcing *(SESIP needle)*	-0.0574	-0.0605	1.0000	
Environment *(SESIP needle)*	**0.4916**	**0.3631**	**-0.1161**	1.0000

Used the dichotomized summated scale scores Results show Pearson's *r* **Bold -** significant p<0.05

Table Appendix E 6.2 Correlation matrix of associations between 3-PRECEDE Factors and HFT use

	HFT use	Enabling	Reinforcing	Environment
HFT use	1.0000			
Enabling *(HFT)*	**0.2642**	1.0000		
Reinforcing *(HFT)*	0.0889	0.0080	1.0000	
Environment *(HFT)*	**0.3716**	**0.2611**	0.0063	1.0000

Used the dichotomized summated scale scores Results show Pearson's *r* **Bold -** significant p<0.05

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CURRICULUM VITAE

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EDUCATION:
Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
DrPH, Environmental Health Sciences

Rutgers/UMDNJ-School of Public Health, Piscataway, NJ
MPH, Environmental & Occupational Health

Rutgers University, New Brunswick, NJ
BS, Biological Sciences

EXPERIENCE:
U.S. Department of Labor, OSHA Dates Employed: 07/2012-Present
Washington, DC- OSHA National Office
Director, Office of Health Enforcement,

- Direct the development, maintenance, updating and classification of guidelines and OSHA Industrial Hygiene Field Operations Manual and Compliance Directives that prescribe uniform occupational health field operations and procedures for OSHA compliance officers.
- Coordinate and oversee technical industrial hygiene assistance to OSHA field to provide technical occupational health advice in the interpretation and application of standards in the field
- Direct evaluation of highly specialized occupational health problems in connection with enforcement assistance operations
- Confer with officials of federal and state agencies to assure coordination and uniformity, and with representatives of employers and organized labor to resolve health enforcement matters.
- Provide authoritative technical information and recommends major changes in the office program for advisory review and executive approval; advise the Director, Directorate of Enforcement Programs, on problems involving regional health

enforcement assistance operations

- Supervise and direct office functions; establish long- and short-term plans, prioritizing and revising such functions as special circumstances dictate
- Establish performance requirements and evaluate employee performance; initiate action to provide for training and development of staff.
- Plan for and assign work to be accomplished by staff assigned to specific occupational health projects; establish specific milestones for the project; provide direction by resolving conflicts in the work process and control work results by means of staff meetings, work conferences and review of finished work projects

U.S. Dept of Labor, OSHA Dates Employed: 03/2011-07/2011*
Washington, DC- OSHA National Office
Acting Director, Directorate of Technical Support and Emergency Management

- Supervise and direct the Directors of several offices including, but not limited to: Office of Occupational Medicine; Office of Occupational Health Nursing; Salt Lake City Technical Center, and Office of Emergency Management
- Direct offices in prioritizing functions that provide technical support to the rest of OSHA including the Agency's enforcement and compliance assistance activities
- Manage budget for the Directorate prioritizing allocation of funds to operations including support for review and approval of variances (i.e., regulatory action that permits an employer to deviate from the requirements of an OSHA standard under specified conditions), and to perform certification reviews for private sector organizations for certain products to ensure that they meet the requirements of both the construction and general industry OSHA electrical standards
- Manage operations that include development of technical guidance such as safety and health information bulletins, OSHA hazard alerts on emerging safety and health issues, and maintenance of OSHA safety and health topics webpages

**This was a 4-month, temporary assignment*

U.S. Dept of Labor, OSHA Dates Employed: 09/2006-06/2008*
Washington, DC- OSHA National Office
Team Leader/Division Chief,

- Plan for and assign work to be accomplished by staff assigned to specific occupational health projects; establish specific milestones for the project; provide direction by resolving conflicts in the work process and control work results by means of staff meetings, work conferences and review of finished work projects
- National Bloodborne Pathogens Coordinator; responsible for preparing standard interpretation and policy clarification letters in response to public inquiries on a wide range of OSHA regulations
- Principal OSHA representative responsible for the development of enforcement policies for occupational exposures to biological agents in laboratories, healthcare and other workplace settings; develop policies for commonly encountered and emerging health issues (e.g., *Mycobacterium tuberculosis*, Anthrax, SARS, Avian Flu, Pandemic Flu and MRSA)

- Responsible for developing policies, practices and techniques for health compliance inspections. Review and analyze health compliance inspections and investigative reports
- Coordinate the provision of technical assistance to OSHA Regional and Area Offices and assures compliance with occupational health standards
- Coordinate various health compliance matters of mutual interest including procurement and use of measuring and sampling equipment and personal protective equipment with the OSHA Directorate of Science and Technology
- OSHA liaison between other government agencies and professional organizations on environmental and occupational health issues; collaborate frequently with CDC, NIOSH, EPA, FDA and organizations such as Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) and the Association of peri-Operative Registered Nurses (AORN)

Voluntarily reassigned as Sr. Industrial Hygienist in 2008 to begin DrPH course work

U.S. Dept of Labor, OSHA Dates Employed: 01/2003- 09/2006; 06/2008-07/2012
Washington, DC - OSHA National Office
Senior Industrial Hygienist,

- National Bloodborne Pathogens Coordinator; responsible for preparing standard interpretation and policy clarification letters in reply to public inquiries on a wide range of OSHA regulations
- Specialized experience setting policy and developing guidance documents on OSHA's Bloodborne Pathogens standard, workplace exposures to biological agents and infectious diseases, including Tuberculosis, Anthrax, SARS, Avian Flu and Pandemic Flu preparedness
- Plan, coordinate and lead conference calls with OSHA Regional Office Bloodborne Pathogens coordinators and staff members from other National Office Directorates, including collaboration with the Office of Occupational Medicine and the Office of Occupational Health Nursing
- Review and analyze health compliance inspections and assist the Director and the Office of the Solicitors in communicating OSHA policies relating to significant cases, contested health cases and compliance cases being presented to the Occupational Safety and Health Review Commission.
- Represent the agency by conducting presentations and teaching safety and health courses to large groups and conferences, including the American Industrial Hygiene Annual Conference (AIHCe) and the American Biological Safety Association (ABSA)
- Co-developed and instructed a Pre-Conference Professional Development Course (PDC) for the American Biological Safety Association (ABSA)
- Key participant in the development of a NIH/OSHA joint training course for assessing safety measures and practices in Bio-containment Laboratories
- Provide updates and clarification on current OSHA policies and procedures to other governmental agencies (e.g., CDC, NIOSH, FDA, EPA)
- Key participant in the agency's strategic planning process for Pandemic Flu. Participate on inter-departmental teams to review the President's Plan on Pandemic

Flu and provide guidance to Agency leaders in the review of plans developed by other governmental agencies (e.g., HHS, DHS, USDA)

U.S. Dept of Labor, OSHA Dates Employed: 09/1996-01/2003
Parsippany, NJ and Ft. Lauderdale, FL OSHA Area Offices
Industrial Hygienist,

- Conducted onsite enforcement inspections of private and federal facilities for the recognition, evaluation and recommendation of controls for safety and health hazards
- Conducted employee monitoring for various occupational health hazards. Utilize various measuring and sampling equipment to assess exposure to chemical, physical and biological hazards
- Recommended abatement measures based on general industrial hygiene principles and hierarchy of controls
- Provide compliance assistance to employers and employees regarding workplace safety and health
- Provided information and assistance to employers and employees on workplace safety
- Liaison between other bodies of government, employers, unions and employees and other employee representatives for ensuring worker safety and health

Township of Irvington, **Dept of Health & Welfare** Dates Employed: 09/1992-09/1996
Irvington, NJ.
Environmental Health Specialist/Sanitary Inspector

- Inspected private homes and public facilities for the presence of lead in coordination with the CDC's Childhood Lead Prevention Program
- Educated parents on precautionary measures for reducing childhood lead poisoning
- Developed and conducted education program informing lead abatement contractors of the hazards of lead poisoning
- Instructed lead abatement contractors on safe work practices
- Performed lead hazard reduction clearance inspections
- Inspected health care facilities, schools and retail food establishments
- Performed inspections in response to community environmental health complaints

TEACHING ASSIGNMENTS:
- OSHA Health Care Course (2004 - 2012)
- OSHA Biological Hazards Course (2004 - 2012)
- ABSA Professional Development Course: Intro to OSHA for Biosafety Professionals (2004 - 2007)
- OSHA/NIH - Essentials of Biosafety: Assessment and Strategies (2006)
- OSHA Expanded Health Standards Course (2003-2005)

CERTIFICATIONS HELD:
- US EPA Hazardous Materials Incident Response Certification
- Certified Safety and Heath Manager (2001 – 2004)

- NJ State Licensed Lead Inspector/Risk Assessor
- NJ PEOSHA Provisional Right to Know Trainer
- NJ State Licensed Sanitary Inspector (1992 - 2004)

HONORS, AWARDS, PUBLICATION:

- Johns Hopkins Certificate in Risk Sciences and Public Policy (2010)
- Johns Hopkins Certificate in Public Health Preparedness (2010)
- U.S. Department of Labor Secretary's Career Service Award –(2009)
- U.S. Department of Labor Secretary's Exceptional Achievement Award – OSHA Pandemic Preparedness Team (2007)
- NORA Partnering Award for Worker Safety and Health – Interagency Taskforce *NIOSH Alert: Preventing Occupational Exposures to Antineoplastic and other Hazardous Drugs in Health Care Settings* (2006)
- U.S. Department of Labor Secretary's Exceptional Achievement Award – OSHA/DOE External Regulation Project (2005)
- Author, *Address deficiencies in bloodborne pathogens exposure management,* MLO-online, July 2009
- Co-authored safety and health article for California- CPA magazine, Sept. 2005